Development of the Perceptual World

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BASIC BOOKS, INC. NEW YORK

Library of Congress Catalog Card No. 60-7746
Manufactured in the United States of America

First printing October 1960
Second printing November 1960

To Ellen and Lois

Preface

This book began as a set of notes for discussions at the weekly research seminars of the Perceptual Learning Project * at The Menninger Foundation. As these research seminars considered more and more research on the role of learning in perception, a conviction grew that the myriad, scattered items of literature on such problems should be brought together into one available source. Moreover, a fairly systematic point of view, a point of view which seemed to integrate the varied studies in the literature, developed from our group's research. Gradually we formal-

* We gratefully acknowledge the support of the United States Public Health Service, which supported our research by a research grant (M-715C) from the National Institute of Mental Health of the National Institutes of Health.

ized our notes and ideas, documenting references and briefly summarizing experimental procedures. These formed the basis for this book.

We must not pass over too quickly the contribution of those research seminars. A vigorous research seminar involves a tremendous amount of give-and-take, of "trying ideas on for size"; of taking positions and of attempting to defend those positions by reference to available experimental literature; of sharpening and refining theoretical ideas; of becoming aware of pitfalls; of developing flexible methodologies; and of genuine constructive criticism. An experimental or theoretical idea may be tossed into the discussion hopper by one member, be developed by the group, and eventually be tested by a member of the group other than the originator of the idea. Indeed, in the flux of discussion it is often difficult, if not impossible, to determine *who* was the originator of a specific idea. We owe a debt of gratitude to the various members of our research seminars, although we alone must bear the responsibility for what is presented here. Among others, we are indebted to Drs. Mary Engel, Riley Gardner, John Santos, James Simpson, and Robert Sommer as well as Mr. Ralph Fisch, Harold McNamara, Martin Kirschenbaum, Charles Snyder, and Fred Snyder.

Our point of view, our theory if you will, did not begin in a void. One of us (G.M.) had struggled with the theory of perceptual learning for many years, considering in particular the role of affect in perception. In a sense the beginnings of a theory had already been established. We found, however, as we attempted to translate this early theory into research, that it had to be expanded as well as simplified. Variables other than affect and motivation had to be introduced; *e.g.*, time relations between perceptual and reinforcement stimuli had to be included. Individual differences in reaction to affective stimuli, changes in incentives and motivation with development of the individual, and methods of dealing with affect-arousal began to take on experimental significance. Our early theory was, in short, expanded to include new variables. On the other hand, we simplified our theory by linking our variables and concepts to experimental operations and we also strengthened our theory by using more and

more "converging operations" to reduce the amount of "surplus meaning" in our theoretical constructs. We have reached a point where we feel that we have something important to present.*

This does not mean that we have settled all issues. Enormous gaps remain in our knowledge; our theory is far from complete, the incompleteness stemming largely from the lack of specific experimental work on a vast number of issues. We are not sure that all of the important variables have been isolated; and we are definitely in the dark concerning the *interaction* effects of the major variables which have been teased out. In fact, throughout this book we have been reluctant to theorize about such interaction effects; it seems appropriate that in our present stage of incomplete knowledge we should look first for major variables and secondly for interaction effects when it seems to be impossible to isolate "pure" variables. The reader should not think that we are apologizing for our theory. We are satisfied that what we do present is worth offering, but we are explaining why we do not present more.

What then does this book consist of? It consists of two major parts. The first presents our theoretical arguments on perceptual learning; the second, an analysis of the molar components of the perceptual act and of how these components are altered through learning. We have tried to be scholarly without being pedantic; we have tried to cover all major experimental *procedures* that have been used, but not necessarily all articles, since many studies repeat the same procedures. We have attempted to present procedures in general, but we have not aimed at giving all the details of presented studies. Specific experimental details can be found in the articles to which we refer. We have not tried to present the various *theories* of perceptual learning, although we find in retrospect that we have used some of the important ideas of such men as Brunswik, Gibson, Helson, Hilgard, Koffka, Piaget, and Woodworth, among others. Although our approach differs considerably from the approach used by each of these men, we have found constant inspiration in their writings; we can scarcely discharge our debt of gratitude.

* Comment by G.M.: About 80 per cent of this book was written by C.M.S., who deserves at least that much credit for whatever is good in it.

At what level is the book written? This book is not designed for use as a textbook, although one might use it for that purpose. As originally conceived, this book was written for psychologists who had had considerable training, either formal or informal, in both perception and learning. However, one of us (C.M.S.) has used multilithed copies as a supplementary text for an advanced undergraduate-graduate course in perception in which Bartley's *Principles of Perception* * was used as a basic text. Much to his surprise the advanced undergraduates (juniors and seniors) were able to read and understand most of this book. Consequently, we are not sure of the level at which it is written. The authors do assume that the reader has already acquired basic information in both perception and learning, and that this book is a fairly advanced theoretical-experimental treatise on the role of learning in perception. It is an attempt to answer Koffka's classical question: "Why do we see things the way we do?" by examining the function of learning in perception. Whereas Koffka and the Gestaltists sought an answer to this fundamental question in *field dynamics*, we seek an answer in *learning*. If we may be allowed to anticipate ourselves, a full answer to Koffka's question involves both approaches; neither approach is sufficient in and of itself. We assume that the reader already knows something about perception as related to the Gestalt field theory, to the Gibsons' psychophysical field theory, and to the dimensionality of perception as developed by Helson. As a *minimum* of background, we would assume that the reader has read such a source as Bartley on perception and such a source as Hilgard † on theories of learning.

Let us repeat that this book is *not* a compendium of all the studies and theories of the role of learning in perception. We have been selective. But we hope that we have chosen with some sense of perspective. There will be a few readers who will agree with what we have written; there will be many who will agree with some things and will disagree with other things; and there will be some who will violently reject everything. If this book has any value at all, it can be judged only in terms of

* S. H. Bartley, *Principles of Perception* (New York: Harper, 1957).

† E. R. Hilgard, *Theories of Learning* (Rev. ed.; New York: Appleton-Century-Crofts, 1956).

whether or not it stimulates research. We shall not feel badly if ensuing research proves us wrong. Our scientific knowledge can only grow through research, and a great deal more is needed in this neglected area of psychology. If this book stimulates further research, we shall judge it a success; if it does not do so, then we shall judge it a failure and must chalk it up to experience.

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Contents

I

Theory and Mechanisms

"Perception" can be legitimately conceptualized in a number of theoretical ways, each approach being as "true" as any other. How one conceptualizes the *relationship* between learning and perception depends upon how one conceptualizes both "learning" and "perception." Accordingly, it is imperative (*a*) that we take a stand on each of these two complex problems, (*b*) that we explicitly put down our conception of perception, (*c*) that we spell out the learning mechanisms that we are going to consider, and (*d*) that we formalize a *theoretical relationship* between our concept of perception and our choice of learning mechanisms. This section attempts to carry out this task, to provide a theory of the role of learning in perception.

I

A Historical Perspective on the Processes of Perceiving and Learning*

The history of a problem often casts light upon the importance of that problem; history provides a perspective for viewing theory. A brief consideration of the history of perceiving and learning can serve as an orientation to our theory of how the perceptual world developed. Without going into the manifold details of history, we shall sketch, in bold strokes, the background from which our theory emerged.

THE EARLY HISTORY

Among sensitive early observers of man's modes of contact with reality, the philosophers of India and of Greece are most worthy

* A fuller treatment of the history of these problems may be found in E. G. Boring, *History of Experimental Psychology* (Rev. ed.; New York: Appleton-Century-Crofts, 1949); and in G. Murphy, *Historical Introduction to Modern Psychology* (Rev. ed.; New York: Harcourt, Brace, 1949).

of a moment's attention. For the Indians, as for the Greeks, the problem was, primarily: How can we make contact with a reality outside our minds? In India the term *maya* (illusion) constantly occurred, whereas in Greece the concept of *eidolons* emerged as a solution to the questions characteristic of the early Greek philosophers: *e.g.*, How can a man's mind form an image or impression of a tree when the man's whole body is not big enough to enclose the tree? The problem of misperceiving and the problem of perceiving went hand in hand. Perception was, so to speak, not taken apart into its components but treated as a given totality which correctly or incorrectly guided man in his commerce with his world. The normal process of perceiving was conceived in terms of the mind's making direct and genuine contact with reality through the senses, which were like doors which open or close, letting miniature eidolons (miniatures of reality) enter or not enter. Man did not construct or reconstruct reality from lights, sounds, pressures, etc.; he admitted it, in miniature, into his mind.

Greek philosophy, like Indian philosophy, moved forward from this kind of problem to the problem of the relation of perceptual knowledge to cognitive knowledge, notably in Plato's enormous emphasis upon ideas of the universal or abstractions, and in the Indian conception of *atman* which, sweeping aside illusion, involves a true oneness of the individual soul with the cosmic soul. The more analytical task of taking the process of perceiving apart and noting how the components might interact to give a functional contact with the environment was of genuine interest to Aristotle. Aristotle had an elementary understanding of receptors and the integration of receptor functions, as he distinguished, for example, between the senses and the "common sense" which gives us twoness when both the fingers and eyes report that there are two objects on the table, a primitive but useful introduction into the world of cognition.

What we should call the experimental approach to perception appeared furtively among the Greeks of the post-Alexandrian period, whose work in optics found some re-echoes in the work of the medieval Arabs. It may be said, however, that the dissection of the process of perceiving with an instrumental study

of stimulus situations on the one hand and of psychological analysis of sensory contributions and integrations on the other was reserved mainly for the era beginning with the seventeenth century. Partly as a result of preoccupations with astronomy, the development of the telescope drew attention to the broad problems of optics for which Sir Isaac Newton went on to see a number of analytical solutions. In the same period, the seventeenth century, Hobbes had vigorously insisted that all higher constructs derive from sensory impressions, whereas Locke restated the medieval schoolman's position that, although sensory content provides the raw materials, there is a higher reworking or process of "reflection" which gives them meaning.

The rebirth of the empirical spirit began with Hobbes. In keeping with this spirit Bishop George Berkeley insightfully suggested that experiences of touching and reaching enter into the perception of the visual third dimension. This era marked the true beginnings of that modern associationist doctrine which states that raw sensory materials are connected together to give the higher compounds known as percepts. The very men, such as Locke and Berkeley, who saw most clearly how this might be done were the ones who were most insistent that some higher order integration process was itself an equally necessary assumption. The dramatic difference between the uncompromising sensationists and those who look for higher integrations appears in the contrast between Condillac, who in eighteenth-century France said that a statute with only the sense of smell could in time develop all the higher intellectual phenomena; and Bishop Berkeley, who looked upon God as the necessary architect of higher integration.

At about this time David Hume began his radical dissection of sensory components which, along with prior associations, give us the course of thought; and David Hartley theorized that the order of stimulus excitations in the brain, *A*, *B*, *C*, *D*, was the cause of their later excitations, *a*, *b*, *c*, *d*, in association, memory, and thought—a classical physiological basis for a systematic associationistic psychology. We have thus begun to see how *a theory of perception leads inevitably into a learning theory.*

We might have traced the development of learning theory

through a somewhat different path, although it would necessarily be a path which intersects here and there with the one that we have followed. Let us look for a moment at this alternative route. Plato turned over to Aristotle the two great laws of association by contiguity and similarity, but Aristotle added association by contrast, without elaborating these principles. In his *Rhetoric* he presupposed the principle of association as a dynamically important guide to the practical leading of men. In a spirit fully worthy of Shakespeare's Mark Antony—and in his discussions of youth and old age and of masculine and feminine psychology—he further used the principles of association. These were, moreover, developed by the Stoics and Epicureans, whereas in their due time the Christian church fathers made use of the principles of association without notably developing them. It was Hobbes who most clearly pointed out that the order in which events are impressed upon our senses is the order in which they are recalled. James Mill, the great systematizer of the classical British association school, carried these ideas still further, while his son, John Stuart Mill, sought a "mental chemistry" in which compounds differed qualitatively from their components. Here and there it began to be glimpsed that, if two complex events each made up of many parts are associated (as when, for example, falcon gives rise to hawk or eagle), there must be anatomical resemblances consisting of beaks, talons, etc., which permit the transition points or pivots to lead from one complex to the other. Association by similarity has, however, come down the ages as the hallmark of the poets' thinking while receiving extraordinarily little attention from the psychologists. Association by contrast might be thrown in as one of the rhetoricians' or politicians' or cartoonists' * or jesters' special devices for making small differences into dramatic and ludicrous contradictions.

THE NINETEENTH CENTURY

The deposit of ancient ideas cast upon the shores of the early nineteenth century included, then, a sensationist's and an inte-

* Honoré Daumier's cartoons vivify the French expression that to know a word one must know its opposite.

grationist's view of perception and a contiguity view of the learning process. For purposes of complete symmetry, we might expect to find likewise an active or integrationist view of learning. We do in fact find some of it among the various writers mentioned, notably Hobbes and Locke, but the essential asymmetry remains. We have a contiguity theory widely accepted by the associationists as applying both to perceiving and to learning, and then we have in addition an integrationist approach frequently and effectively applied to the process of perceiving.

The close of the eighteenth century etched in more firmly the contours just described, notably through Immanuel Kant's memorable emphasis upon activity and unity in the process of perceiving (a Greek idea, as we saw, but one that had been much enriched by the German tradition from the time of Leibnitz). And Kant had gone on to throw aside practically all of the atomizing and sensationizing elements in the associationist tradition. If we keep these points in mind we shall be somewhat astonished to note that on German soil there now began at the beginning of the nineteenth century two radically different empirical approaches to these phenomena—the one in the field of perception, led by E. H. Weber, the other in the field of learning, led by J. F. Herbart.

Weber, a physiologist at Leipzig, experimented on the muscle sense and on the sense of touch from a quantitative point of view. As all students of elementary psychology are informed, he and his ardent admirer, G. T. Fechner, developed fundamental experimental methods for the determination of conditions under which a subject may tell which is the longer of two lines, the heavier of two weights, the louder of two sounds, etc. Through this conceptualization and the experimental methods which made this budding new science of psychology aspire to become like its big brother, physiology, and its still bigger brother, experimental physics, came the elementarism in the field of perception as in all other fields against which the late nineteenth century and the twentieth century have so vigorously rebelled. It was the putting together of sensation units that made Fechner's system both famous and infamous, just as it was the combination of sensory components in the more mature work of Wundt that

made psychology look like a synthetic science. As we pen these few words, however, we are forced to note an extraordinary contrast between the elementarism in method as used by Weber and Fechner and the emphasis on integration as German philosophy had come to know it, especially in the days since Immanuel Kant. Even the staunch, no-nonsense-about-him Helmholtz was a close student of Kant, and an overwhelming majority of the leading figures in the new German experimental psychology had an important place for a unifying or integrating act which ran through perception, memory, and the thought processes and, of course, the field of affect and action. The experimental dissection of perception proceeded up to a certain point with relatively simple perceptual apparatus, but then in its higher reaches recognized the great need for something more.

But if we retrace our steps for a moment to J. F. Herbart, we find that this profound student of the learning process had to have his elementarism and his contiguity principle in a pure, clear, and workable form and that he could, over generations of psychological history, maintain a "connectionist" conception of learning while the psychologies of perception were reluctant to carry this principle through to its final conclusions. Let us see how this came about.

Herbart, drawing as did all Germans upon Leibnitz and the chain of thinkers culminating in Kant, undertook to show that impressions form into clusters by contiguity and that sequences of clusters could be established through the course of the mind's flow, each cluster being composed dynamically of sense elements, each having its own intrinsic tendency to struggle into consciousness, just as clusters likewise compete for a place in the sun with one another. The elements, passive from the time of the Greeks, have become active and jostle with one another. For all that, they are connected, they form patterns; under certain conditions, they coalesce. Those which are connected with consciousness have a return thrust, a tendency to push back again when the downward thrust which keeps them out is momentarily weakened. As more and more elements and clusters are combined, they form an "apperceptive mass," the funded content or total dynamic balance of sensory assets of the individual; his

stock of ideas, his store of attitudes, prejudices, his unconscious assumptions, etc. Any new idea can therefore be taught the child or adult only insofar as the way is cleared of obstructions and only insofar as there is a positive association between the incoming units and those which sit comfortably in the living room waiting to receive the guests. You can teach what the individual is ready to learn:

> Men must be taught as if you taught them not,
> And things unknown proposed as things forgot.*

We have here more than we could have asked for, since we have not only a vigorous and consistent elementarism and connectionism as the basis of learning but its dynamic basis to boot; that is, each component has its own tendency to make its own contacts or to exert its own dissociative or inhibiting effects upon nearby ideas.

This latter point was a little more than psychology was ready for. It was only psychoanalysis that fully grasped the importance of this dynamic attribute. The experimental psychology of the late nineteenth century gratefully took over the connectionism and began to do something with it, as, for example, in the association test devised by Francis Galton and developed by the laboratory of Wundt at Leipzig. Of special importance were the brilliant and systematic experiments of Ebbinghaus, who invented the most satisfactory elements yet available for the study of association; namely, nonsense syllables, and grouped these in chains of various sorts to be presented at a uniform rate for memorizing, and tested the results under many standard conditions. The tendency to forget lists of various lengths at various rates threw abundant light on a great many types of facilitation and inhibition which various learned sequences might have upon one another. It was these experiments of Ebbinghaus, soon to be joined by those of G. E. Müller, which gave the experimental psychology of the learning process essentially its modern form. It was "connectionist" through and through; and although one finds here and there, as in G. E. Müller, due recognition of an

*Alexander Pope, *Essay on Criticism,* Part III.

integrating or unifying principle, the experimental methods continue to speak eloquently about what the real assumptions of the scientific method must be, namely, those of elementarism or atomism.

Thus, with these seven-league boots we have come to a late nineteenth-century psychology of perception which is elementaristic and secondarily integrative; and an elementary psychology of the learning process which likewise is essentially elementaristic, although with some incidental recognition of a unifying principle. A man who adopts an elementarist or connectionist view in the field of learning is likely to adopt it in the field of perception and vice versa. This is in fact what we find. Most psychologists in this period may be classified in terms of their basic assumptions about the way in which the mind is to be regarded and about the suitable research devices which may properly be applied to it. In general, the German experimental psychologists of the period carry a viewpoint from perception into learning and from learning back into perception which involves no gross conflicts.

Not that the two fields of research were closely related—but through their background of understanding of the history of psychology and especially of Herbart, Weber, Helmholtz, and Wundt, experimentalists see no fundamental obstacle to a unified psychology. This does not mean that in the course of their daily work in the laboratories or their writing of reports they treat perception and learning as twin brothers. On the contrary, the study of perception involved an enormous amount of attention to sensory detail which was largely irrelevant in the learning process, and the study of learning called for an enormous amount of attention to the complex stimulus materials, such as words or nonsense syllables, which were to be connected, and which for the most part were not reduced to detailed, sensory analysis. Experimentalists, moreover, tended to assume that the main landmarks of the perceptual process were given by the anatomy and physiology of the sense organs and by elementary receptor functions, with some belated recognition of some higher order integrating activities, whereas the study of memory was based largely upon quantitative parameters, such as exposure time, time

between exposures, lengths of lists, frequency of repetitions, etc., which were largely alien to the field of perception research as such. There was, in general, small recognition of the fact that a perception theory should be a learning theory and that a learning theory should be a perception theory.

Actually, it was among the students of psychopathology, notably of the aphasias, that the close relation between perceptual aberrations and learning was most strikingly recognized. Despite this functional dissociation between perception psychology and learning psychology, it cannot be said, however, that there was any fundamental failure of communication, only a certain sluggishness or slowness to move from one area to another. The basic position of the man as a connectionist or as a unifier was likely to be clear.

THE TWENTIETH CENTURY

All this became very evident indeed when the revolution of Gestalt psychology hit the laboratories and the classrooms after 1912. Wertheimer first showed the insufficiency of an elementarist approach in the field of perception, and the same Wertheimer constantly showed the inadequacy of elementarism in the study of thought. The same Koffka who looked for unities in perception looked for unities in the growth process. The same Köhler found in both the sudden insight of the chimpanzee and the bio-electric fields of retina and brain a unifying principle which overrode all elementarisms and all fragments of experience, whether sensory, affective, or motor. We may generalize by saying that, in the systematic psychology of the period, perception and learning were viewed within a common frame of reference, despite the fact that in the experimental labors of men working in the two fields the phenomena of perception threw relatively little definite light upon the phenomenon of learning and vice versa.

Actually, the functional unity of the fields of perception and learning for the experimental and systematic psychologist was not fully recognized until there had been time to assimilate the significance of Köhler's early work and that which followed im-

mediately upon it. We refer, not to the endless arguments about the nature of sudden insight reported to have occurred in the learning process of chimpanzees, but rather to the much more fundamental fact that it was in the forms of *perceptual learning* that Köhler found the forms of *motor learning* which so completely transcended the well-known trial-and-error patterns emphasized by Thorndike and his colleagues. The question of the rightness or wrongness of Köhler's views about insight pales into utter insignificance in comparison with the demonstration that perceptual changes may be regarded as the basis for motor changes.

There is no intention of implying that Köhler individually, or Gestalt psychology in general, was the sole instigator of our modern interest in the relations of perception to learning. As already noted, psychopathology had drawn some important conclusions as to the implications of one for the other. Psychoanalysis in particular had utilized classical association psychology both in its affectless form and in its drive-determined form (Herbart) in the early concept of free association and the conception of hallucinatory and other primary-process forms of perceiving in the infant.

It would be tedious to try to recount all the components in the rich texture which constituted the early twentieth-century fabric of a newly conceived system of relations between perception and learning. Major importance must nevertheless be given to Gestalt psychology, because of the explicit way in which the psychology of the learning process was conceived as following from the organized nature of the process of perceiving and in which the organized character of perceiving was then discovered in the learning processes themselves.

We ourselves in the course of our training found many inspirations in the direction of weaving the two systems of concepts together, the inspiration notably coming from Koffka, Köhler, from Lewin, from Piaget, from Sherif, from the Gibsons, and, in a highly personal form, from Osgood, Stagner, Tolman, and Woodworth. No attempt will be made to seek out the intricate, interlacing pathways of modern influence in these fields. It is sufficient to say that today the influence of the learning

process upon the act of perceiving is widely recognized and urgently calls for experimental analysis. We may learn to understand perception better if we see its parameters defined in terms of learning as well as in terms of structural components and physiological units which come with the living package itself. We may understand learning better if we realize the role that a plastic and modifiable process of perceiving may impose upon basic motor learning. In short, we may see the integrity of the flexible and ever-changing living system more adequately if the sharpness of the classical distinction between perception and learning is somewhat modified.

2

A Point of View

Although psychology has an abundance of models of learning (5, 6, 9, 20, 24, 32,* etc.) there have been few attempts (1, 2, 3, 9, 13, 22) to analyze the role of learning in perception. A *general, systematic* theory of perceptual learning does not exist at present. This lack of systematic models of perceptual learning is not surprising. There is an equally great lack of experimental data, reflected in enormous gaps in our knowledge. Before a serious theory can be constructed it is necessary first to pull together what we do know and to assess the things we do not know;

* Numbered bibliographic references will be found at the end of each chapter. Commentary notes, indicated by asterisks, daggers, etc., will appear at the foot of the page.

then, to *guess* about both the things we do not know and how these nonexistent "facts" might function. Only research on these guesses can tell us where we have guessed wrong, where we have guessed accurately, and what we shall have to reconsider.

The purpose of this book is to assemble the available evidence on perceptual learning and to give some guesses. Like all authors, we are biased. We have our own point of view. We shall try to make this outlook explicit, but we hope our biases do not lead us to the arbitrary exclusion of evidence contrary to our point of view. We are *not* going to present a full-fledged theory; our tentative guesses are our only theory. Premature theories cloud both issues and data, and serve little purpose except to allow authors to believe in the magical power of their words.

THE MEANING OF "PERCEPTUAL LEARNING"

The meaning of the term "perceptual learning" can be derived by examining the meaning of two basic concepts—learning and perception. Although there is sharp disagreement among psychologists as to the full meaning of both perception and learning, there are certain points about both on which there is substantial agreement. Consequently, we shall use these points of agreement as rallying points and shall stick fairly close to those points throughout this book.

First, let us examine "learning." The organism functions or performs differently as a result of certain conditional experiences, and not as a result of others. Hilgard defines learning in this way: "Learning is the process by which an activity originates or is changed through reacting to an encountered situation, provided that the characteristics of the change in activity cannot be explained on the basis of native response tendencies, maturation, or temporary states of the organism (*e.g.*, fatigue, drugs, etc.)" (17, p. 3). This distinction between observed performance and inferred processes of learning is recognized by Hull (20), Tolman (32), Verplanck (33), and others. Learning is an inferred process, the inference to be drawn only when certain conditions are met.

The activities which become altered need not be directly ob-

served, but they must be *logically* (formally) linked to things which can be directly observed. When specified contingency relationships exist between various environmental events and various organismic activities, the ground is set for learning. That is, the minimal *necessary* conditions for learning are present. The most time-honored of these conditions is close *contiguity* between stimuli and subsequent activities. It is also recognized that motivation to carry out the "to be learned" activities markedly affects the rate of learning, and that "reinforcement" also facilitates the changes in activities. We are not nearly so sure of *sufficient* conditions and are willing to accept the "weaker law of effect" as proposed by Meehl (23). The weaker law of effect is the conception of reinforcers as those events or operations which have been experimentally found to be reinforcing. It is weak in the sense that necessary and sufficient conditions are not sought after—the experimenter uses those things as reinforcers which have been found to reinforce in the past.

Perception is also an inferred process. It, too, is unobservable, except in a phenomenological sense. That is, the *perceiver* observes his own percepts. As a term, perception denotes a *process* and a *product;* these two are usually called *perceiving* and *percept* respectively. Some of the controversy about perception revolves around perception's two meanings. Some examples might clarify this point. Titchener defined it this way: "A perception is primarily a group of sensations, arranged by external nature" (31, p. 9). Woodworth and Schlosberg also refer to perception as a product when they write: "Perception is not meant to describe a known process. It identifies a *result* achieved by the organism, not the process of reaching the result" (37, p. 403) [ITALICS OURS]. On the other hand, Helmholtz (15) wrote of "the psychic acts of ordinary perception," clearly referring to the process by which percepts are achieved.

Like learning, perceiving is to be inferred as a process under certain conditions and not under others. These inclusions and exclusions are necessary to distinguish perceiving from other cognitive processes, such as memory, judgment, and thinking, as well as from overt behavior (18). Perception is inferred from behavior and the conditions of behavior, just as learning is in-

ferred from changes in behavior. Some of the more important conditions for inferring perception have been outlined by Hochberg (18) and Garner, Hake, and Eriksen (7). It is universally agreed that a physical stimulus must be present and excite some sense receptor or receptors before perception occurs. A sense receptor may be stimulated without perception occurring but perception never occurs without prior sense receptor stimulation. It is further agreed that perceptual traces last for a short time after removal of the physical stimulus, changing into memory, and that continuous presence of the physical stimulus makes it more likely that one is dealing with perception.

Proximal stimulation alone, however, is not enough; some overt response must be observed which *cannot* be made equally well in the absence of the stimulus (19). If it can, then one is most likely dealing with either memory, hallucinations, or response properties, and not with perception. Ordinarily one response, or a limited number of responses, is obtained from which one can infer the transformation of the stimulus properties into perceptual properties. And *if* the inferences drawn concerning perception (the transforming process) are "valid," then other responses should be obtainable which reflect upon perceptual properties other than those immediately inferred. For example, if a subject reports that one of two alternatives is "figure" and the other is "ground," then stimulus generalization should occur along the dimensions of the figure more than along those of the ground. Another example: when a subject reports seeing a Necker Cube going from right to left he should also be able to report (other responses) that the angles are such and such and the lines "converge" to certain points. These additional responses which could be collected and the methods used to gather them form converging operations (7). Enough of these converging operations should be carried out to permit enough inferences about perceptual properties to form a logically coherent picture.

Perceptual learning may be defined as a change in the status of the logically inferred perceptual state or process of an individual as a result of successive applications of the operations of a learning paradigm. Although much of this book is devoted to learning to perceive nonveridically, we do not imply in any sense

that normal perceptual learning moves toward such a state. In any learning experiment it is easier to demonstrate learning if the subjects are trained against their natural preferences. Since most adults and children have already established veridical perception to a large degree, it is merely easier to demonstrate learning to perceive nonveridically. We believe the *process* of learning is essentially the same, although there are obvious differences (in the role of reality structure and feedback) between learning to perceive veridically and learning to distort reality.

PERCEPTION AS PROCESS

Earlier we spoke of perceiving as a process; yet we have not outlined our conception of this process. Like Bevan (2), we prefer a formal construction of perception in which the formally conceived properties are logically related to observable behavior. Here we shall present only our formal concept of perceiving as a process. In later chapters we shall relate the properties of our formal constructs to observable operations and behavior.

Perceiving is a psychological process, with parallel physiological events which are isomorphic (22) with it. This automatically commits us to a dualism of description (though not to a mind-body dualism). As a process, perception is extended in time and consists of a series of interdependent subprocesses, or stages, which can be partially ordered in their succession. The *first* stage is preparatory in nature. Allport (1), Bruner (3), and Werner and Wapner (35) contend that the "sets," "hypotheses," and "sensoritonic" states of the individual, which exist *prior* to proximal stimulation, influence profoundly what happens later in the perceptual process, under certain conditions. People do not *randomly* search for or seek to avoid significant sources of stimulation, just as attention is not directed *uniformly* to all possible stimulus sources in an environment. Just as there is an ecological distribution of stimulus events (4), there is an ecological distribution of perceptual search and of attention. Perception as a process begins here, prior to receptor stimulation. Stimuli preceding the perceptual stimulus have set up perceptual traces, which are still lingering; pre-existing motivational states

have altered thresholds and directed searching activity; and prior experiences have altered the parameters of the perceptual function. All perception occurs in a rich, dynamic, ongoing context, and a thorough understanding of the perceptual process demands that we examine the role of expectancies and sets.

The *second* stage involves the "moment before stimulation" and the activities which prepare the organism for receiving stimuli. It is a cardinal point in our thesis that stimuli present or just preceding those which activate the adjustment phases of perception will, in time, activate these phases in their own right. Stimuli in the everyday social environment which are at first without specific significance come in time to have for the child a definite attention-getting, a definite "encouraging," or a definite "threatening" value. The child takes on a specific posture or stance with reference to significant stimuli. In other words, the acts of attention which are at first given to a relatively small number of native attention-getters are soon indefinitely multiplied. Thousands of events become attention-getters. Insofar as the objects originally attended to are satisfiers, the objects associated with them elicit the approach behaviors which went with the original attention-getters. Those stimuli which are associated with approach behaviors tend to elicit approach responses, and those associated with withdrawal elicit withdrawal responses.

There is, then, a *prima facie* reason to believe that the sensory apparatus will be modified so as to get more of certain kinds of excitation and to get less of certain other types of excitation by virtue of the principle of association or conditioning alone, and without benefit of any higher theory. Far from controverting the Gibsonian principle (9) regarding the progressive evolution of the perceptual response in a veridical direction, we are inclined to believe that this increasing veridicality arises in considerable measure from the fact that attention is deployed more and more in the direction of significant objects. We believe, in other words, that the visual field is structured not by a passive process of continuous maintenance of a fixed stare, or even constant minute movements of the eyes, but by virtue of the fact that the various components in the visual field tend to interact, and each one tends to act as a conditioned stimulus for others nearby which

elicit similar behavioral adjustments (13). We find it hard to believe that sheer successive stimulation of the retina could cause the gradual emergence of a perceptual field. Most of the significant associative work that is done under conditions of repeated visual stimulation is the establishment of meaningful patterns in the environment which involve meaningful patterns of search. The retinal excitations are associated with acts of exploring, turning the head, reaching, giving, receiving, and the rest of the normal pattern of organism-environment interchanges. All these offer abundant opportunities for the establishment of rich textures of conditioned attentional responses to meaningful objects, and all involve the progressive differentiation and integration of visual fields, which in turn become integrated visual worlds (8).

From such a viewpoint, the affective or impulsive aspects of the searching or attending processes become too evident to ignore. It is because the organism is immersed in the environment, which means so much for its biological needs, that the innate attentive-preparatory responses are made, and the affects are organic expressions of the approach and avoidance reactions which prepare the individual to *select* from the multitude of stimuli about him (17). It follows, therefore, that the conditioning of these preparatory, searching responses represents a molding of the attentive-preparatory processes by affective stimulation; and consequently the individual's expectancies or "hypotheses" lead to a selectivity in reception.

Expectancy does not end when another phase of perception begins. There is actually no sharp dividing line between expectancy, attending, and reception, unless for convenience one takes the occurrence of a proximal stimulus as a point of departure. In this *third* stage of the process of perceiving there are built-in determinants, such as (*a*) the autochthonous functions of the receptor organs, (*b*) the characteristics of the projection areas linked with the receptors, and (*c*) the dynamic interplay of receptor and projection-area functions. These factors are not perfect "givens" at birth, but depend upon maturation of organs and function under the impact of repeated experiences and normal growth patterns (13, 25). Such determinants provide the "content" of perception such as the colors we are capable of

seeing, the odors we are capable of smelling, and the sounds we are capable of hearing. Man can experience colors only over a certain range of the spectrum; he can hear sounds only within a certain range of frequencies. As Johannes Müller contended, there are "specific energies" which give rise to specific qualities of experience. Just as our sensory receptivity is limited, so our brains can yield only those sensory experiences for which there are specialized cortical projection regions.

Whatever perceptual learning can take place *must* take place within the limits or capabilities established by his receptor-projection organs. Perceptual learning cannot provide content; * it can only alter the organization and function of content, and even the extent of this process is limited by the receptor-projection system. These limitations, however, are not perfectly inflexible. There is a small amount of evidence that the so-called autochthonous functions can be altered somewhat through learning, as we shall see in Chapter 10. Individuals can be made more sensitive (within limits) or less sensitive (again within limits) at the receptor-projection level of the perceptual process. We will not discuss the physiological aspects of the "reception phase" of perceiving in this book since there are several excellent sources (*e.g.*, 27) on such variables. In a later chapter, however, we will present the evidence for the modification of sensory factors through learning.

Our *fourth* stage is not differentiated sharply from the third. Indeed, it overlaps with the third stage to a great extent and continues until the full structuring of a percept is reached. We call this the *trial-and-check* phase, following Woodworth (36). The main observable feature of this phase is a short but measurable time-lag between reception and final percept. As the amount of required trial-and-check decreases, the time between reception and final percept decreases. Conceptually, this phase is characterized by more than a time-lag. Autonomic activity is triggered which subsequently feeds back into the perceptual process both by (*a*) raising or lowering the over-all level of sensibility and (*b*) functioning as a stimulus in the background context just as

* This is true only in a broad sense. Perceptual learning can provide new content in the sense that perceptual differentiations produce new experiences.

other stimulus traces do. Unconscious inferences (Helmholtz, 15) are made. Tentative inferences or hypotheses, as Bruner (3) would call them, are tested and are probably accepted or rejected on the basis of their congruity or lack of congruity with the surrounding context of perceptual, memoric, and autonomic traces. In addition, trial-and-check may involve further search for information from the environment, especially when the environment is extremely impoverished.

The *fifth* stage of the perceptual process, as we conceive it, is the consolidation of stimulus traces. We doubt that all of the input is consolidated; a "sample" is probably consolidated eventually into a structured percept on a single "trial."

Repeated experiences consolidate more and more samples. The samples (or, at a physiological level of explanation, "cell assemblies" [13]) are not consolidated in isolation. Rather, all effective traces including autonomic, proprioceptive, and other exteroceptive traces are consolidated. Studies by Penfield and Rasmussen (28) point vividly to this aspect of consolidation.

This last part of the process involves "meanings." In a sense this is a revival of the old core-context theory of meaning as espoused by Titchener (31). It differs from the older theory in that motor activity contiguous with perceptual activity is a more decisive component of meaning, as proposed by Osgood (27). Osgood is correct in assigning perception and meaning to a shared no man's land between sensation and response. There is no sharp distinction to be drawn between the two in their biological function, their origins, or their content *unless* one formally limits perception to purely autochthonous functions.

Our last stop on this brief survey of our formal conception of perception does not deal entirely with perception. This is behavior. Behavior is dull in and of itself; but what is behind behavior is exciting. Even Skinner (29) admits to a curiosity about the covert forms of stimuli, responses, and reinforcements which control behavior. Behavior does not always permit inferences that perception or other forms of cognition have intervened. Some responses, even complex ones, may be reflexive in nature. Other responses may be emitted without any appropriate physical stimulus being present, as in the case of a pure

operant, and again do not reflect perception. However, the general class of responses emitted in the presence of proximal stimuli does permit inferences about some aspect or another of perception, unless, of course, the contingency relationship is immutable, as in the case of unconditioned reflexes. By manipulating the operations one performs to obtain this general class of behavior and carefully recording the specific changes in behavior, one can study either perceiving or percept. It is now our task to specify as concretely as possible the ground rules of logic that link our operations, the behavior we observe, and our formal concept of the perceiving process.

PERCEPTION AS AN ACT

As already noted, individual human beings "know" the content of perception in that a percept is an event which is experienced. An individual can introspect upon perception and, by so doing, discover his own idiosyncratic perceptual world. Unfortunately, introspection gives only fleeting information about the process of perceiving by which percepts become fully structured. The use of words such as "perceiving" and "process" implies that *activity* intervenes between stimulus input and final percept. This has led some psychologists to speak of perception as a response. This is particularly true of ardent behaviorists who wish to eliminate "experience" from the field of psychology. These behaviorists equate perception either with an overt report on what is perceived or with an implicit response to stimulation. In either case perception is assumed to have responselike properties; that is, a perceptual response is assumed to function more or less in the fashion of an overt skeletal-muscular response. We can accept neither of these two approaches, against which we submit the following arguments.

The process of perceiving is not a simple response. It is true that perceiving, as activity, takes time to complete; there is a short but detectable lag between stimulation and the eventual percept. However, perceptual activity does not lead to a percept which duplicates the physical properties of the stimulus. More precisely, the activity does not directly transform physical

energy into a percept; the transformation is much more complex than that. The incoming stimulus energy is operated upon so that a new structure is brought into topological mapping with it. This aspect of perceptual activity bears a striking resemblance to an instrumental act. Whereas an instrumental act is identified by a transformation of the physical environment into some new form and is not identifiable by any particular skeletal-muscular action, a perceptual act is identified by the transformation of the perceptual world into some new form. This final result can be achieved by many specific activities, just as the results of an instrumental act can be brought about by a variety of motor actions. An instrumental act restructures the physical environment; a perceptual act restructures the perceived environment. It would be inaccurate to refer to either as a simple response.

Just as an instrumental act can be broken down into components, so a perceptual act can be analyzed. In general, an instrumental act includes all events, taken as molar units, which eventuate in an alteration of the physical environment, or alternatively which operate during the alteration of the environment. A perceptual act should include, similarly, all molar events which take part in the structuring of a percept. These molar events can best be identified by their position in the temporal sequence of events. We have outlined the sequence, but it will do no harm to repeat briefly the sequence as we have conceptualized it.

The perceptual act begins before stimulation; it begins with the individual's expectations about future perceptions. Expectations mark the initial preparatory aspect of the perceptual act. *Perceptual expectation* is the first molar unit of the perceptual act, a unit which continues at least until the percept is achieved. As a unit it merges with and partially directs still another molar unit of the preparatory phase, that of *attending*. Although we may speak of the attentive act, attending is closely linked with the other events which comprise the perceptual act. In point of time, attending begins the moment before stimulation and continues during stimulation. Stimulation itself critically affects the final content of perception; *sensory reactions* are therefore the third stage and should be taken as another molar unit. Between

reception and the final percept there "exists" * still another component which, after Woodworth (36), we call *trial-and-check.* In this molar unit "hypotheses" (3) are tested, unconscious assumptions are checked, and materials supplied by the sensory process are articulated with previously stored memoric traces. During this phase, new information sources are triggered which feed back both into trial-and-check and into the final stage of percepts. This new information often comes by and large from proprioceptive and autonomic sources, although it may come from further visual (and other) searching. The arousal of these sources and their subsequent flow back into the perceptual act is usually termed simply *feedback.* This molar unit merges with the final molar event, that of *conscious perception* itself. This final unit is too complex for us to consider in its entirety, but we shall later consider a basic component which has classically been termed "figure-ground" organization. The molar components of the perceptual act are, in summary: (*a*) perceptual expectancy, (*b*) attending, (*c*) reception, (*d*) trial-and-check, and (*e*) final perceptual organization.

For illustrative purposes we have diagramed in Figure 1 the perceptual act in terms of its molar components.

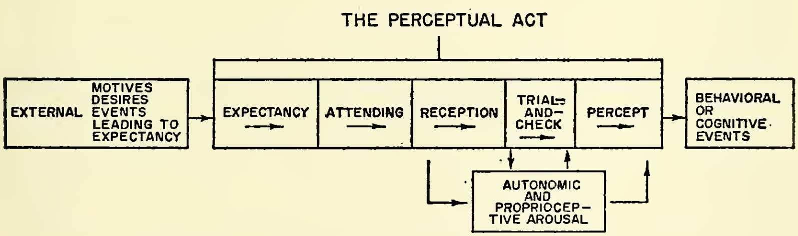

FIGURE 1. *Diagrammatic schematization of the perceptual act.*

The arrows indicate the major transitions between expectancy, attending, reception, trial-and-check, autonomic and proprioceptive arousal, and the final structured percept. Admittedly, the

* By "existing" we mean that there are operations which can measure a process or event.

perceptual process, the process of structuring stimulation, does not consist of way stations which are rigidly separated from one another. There is overlapping and articulation between the subprocesses, and many more arrows could be drawn. Indeed, we find it convenient to define perception as the structuring of stimulation, and percepts vary considerably in structuredness. As such, we are dealing with "perceptuality" rather than with some discontinuous event. As noted long ago by William James (21), perception seems to flow in time, or as noted by Titchener (31), perception has the property of protensity (extension in time). Our schema is to be used as a mnemonic device, not as a map of actuality; as such we may speak of molar units within the perceptual act. All the components appearing at the extreme left in Figure 1 (motives, desires, etc.) can be conceptualized as forms of "readiness" leading into "expectancy."

MOTIVATION—ITS ROLE

Each of the molar units described so far is modifiable, to some degree, through reinforcement, under the impact of *motivation*. As these units are modified, the perceptual act itself is modified. Scattered throughout the varied literature, including developmental and experimental studies, theoretical treatises, psychoanalytical and psychiatric papers and books, there is rich, fertile, but unorganized information about how learning (usually under the influence of motivation) influences the molar components of the perceptual act. This information is so scattered and disorganized that few people know of its existence or scope. One might say that the major aim of this book, its *raison d'être*, is to pull together and integrate this information into a theoretically consistent frame of reference, incomplete though it may be.

Since the various components of the perceptual act are not affected to the same degree by the various factors in learning, including motivation, reinforcement, and practice, we must consider each of the components separately. By so doing we can better evaluate how motivation and learning influence the overall perceptual act.

Allport (1) has stressed the specific question: "How can motivation operate *directly* upon perception?" While this question is important, the more general question of the role of motivation in perception is more important. We need to answer both. Indeed, no conception of perceptual learning is possible without some guess as to the role motives and needs play. William James clearly saw this, and wrote: "No sensible qualities are discriminated without a motive" (21, p. 252). Our needs prompt us to seek satisfaction of those needs; in order to carry out the necessary actions, we must use information present in our environment as given by our perceptions. In a real sense our perceptions coordinate our actions with our environment so that we can successfully meet our needs. This is not the full story, however. Although hunger, thirst, and sex are often regarded as the primary motives, we prefer to extend the list to include curiosity (11) and the need to maintain exteroceptive contact with the environment (14).

Through evolution, man has acquired a sense of smell inferior to that of rodents, a sense of sight inferior to that of birds, and a sense of hearing inferior to that of dogs. On the other hand, the unfolding evolutionary process has given man more highly articulated perceptual and cognitive processes which free him from the tyranny of both his environment and his needs. Even without reference to language and thought, perception provides man a coordination between his needs and his environment which is not available to other animals. But motivation also regulates perceptual search for various classes of stimulation, and thus partially governs the probability of sensory reception. It must also raise or lower the general state of sensibility in addition to influencing special areas of sensory receptibility. Motivation also probably governs the rate of trial-and-check which intervenes between reception and percept. And eventually stimulus cue samples from the internal states of motivation become attached to percepts themselves so that an increase in motivation alone can trigger a perceptual class of events.

Motivating stimuli or events can also *prevent* percepts from being fully structured. An electric shock is motivating to an

organism to escape or avoid the pain which ensues. If avoidance is possible the individual is motivated to discriminate actively those stimulus cues which serve as warning signals that shock is about to begin. In avoidance training, perceptual learning is motivated. In escape training—for example, where there is no possibility to avoid shock—the shock motivates flight activity and disrupts whatever trial-and-check is in progress, as suggested by Smith and Hochberg (30). In this case the motivating event—the shock—disrupts the full structuring of percepts. Intense hunger, thirst, or sexual needs can initiate such intense motor activity that the perceiving process is disrupted and perceptual learning is interfered with. Indeed, one might speak of perceptual extinction as occurring through the competition of overt actions with perceptual acts.

To complicate matters still more, we must recognize that an individual's motivation system changes with maturation and learning (34). Motives are acquired or altered. Children acquire strong social motives. Social approval becomes an incentive as well as a reward. The child who is ignored by his parents while they are having guests will literally stand on his head to get their attention. Strong social disapproval comes to be anxiety provoking; and alleviation of this unpleasant state of affairs "moves" the child to alter either his perceptions or his actions or both. The entire hierarchy of motivations changes with age, and the various reinforcement stimuli change as to their relative efficacy in producing learning. One cannot possibly evaluate the role of motivation without considering developmental changes in motivation.

REINFORCEMENT OF PERCEPTION

The concept "reinforcement of perception" was strongly advocated by R. S. Woodworth. He wrote: "The perceptual function is an elaboration of the receptive process, adjusting the organism to the objective situation rather than merely to the stimuli received. To avoid the supposed introspective connotations of the word *perceive* I have sometimes substituted the word *register*. . . . Temporary registration goes on all the time and

shifts with each change of scene, but for the relatively permanent registration which we call learning and retention some reinforcement is necessary" (36).

We agree with Woodworth. But our agreement does not settle any issues. There is a basic problem left unanswered. The problem is: How do reinforcement stimuli "fixate" perception; or, phrased another way, what are the conditions under which reinforcement is effective in altering an act of perception?

The answers to these questions are not easily given. We have already sketched our conception of the perceptual act, but we have not defined reinforcement—which has a multitude of meanings in and of itself. By "reinforcement stimuli" we do *not* mean stimuli which reduce drives; rather, we accept the Guthrie-Skinner-Estes concept of a reinforcement stimulus as one which preserves some act and by so preserving alters the probability of that act's occurring again.

As we see the problem, a vast number of stimulus events can function as reinforcement stimuli under certain conditions. Stimuli which reduce a need state can certainly function as reinforcers; those which have acquired symbolic states of "goodness" (Osgood) can also reinforce; those which add dynamogenically to some ongoing activity also reinforce; those which the organism typically approaches or avoids are reinforcers; and those which arouse affect are reinforcers. There are certainly some stimulus events which are affectively neutral and yet act as reinforcers; but those which do arouse affect are all reinforcers. We agree with Young (38, 39) that hedonic tone is the best single indicator as to whether or not a stimulus will function as a reinforcer. Indeed, the research of Miller (24) and of Olds (26) points more and more to affect arousal as the event most worthy of emphasis in the ultimate construction of a "strong" law of effect. In any case, all of these criteria *overlap* in mapping out the domain of reinforcement.

Perception itself can function as a reinforcer, according to Woodworth:

> Perception is always driven by a direct, inherent motive which might be called the will to perceive. Whatever ulte-

> rior motives may be present from time to time, this direct perceptual motive is always present in any use of the senses. It is impossible to look without trying to see or to listen without trying to hear. To see, to hear—to see clearly, to hear distinctly—to make out what it is one is seeing or hearing—moment by moment, such concrete motives dominate the life of relation with the environment. . . . When the goal of such a search is attained, strong reinforcement is revealed by the observer's cry of satisfaction and later by his excellent retention of the discovered figure (36, p. 123).

The act of making closure, of coming to grips with the environment, terminates the perceiving process, and the percept literally stops the perceptual act. In a Guthriean sense the percept is a reinforcer in such cases. Man constantly strives to organize, to structure his environment, to make order out of chaos. And when, in the midst of his struggle, he masters an impoverished environment, he is gratified. If Hebb (14) is correct, man needs varying exteroceptive stimulation. Constant, uniform stimulation, as in sensory deprivation experiments, is already structured for the observer; what he needs is *to structure* the environment—not have it ready made. Constant, uniform stimulation frequently leads to stimulus adaptation so that the stimulus is no longer effective.

Hilgard suggests two possible goals in perception which might also control perceptual learning: "(1) *The achievement of environmental stability,* and (2) *the achievement of clarity and definiteness in perception.* . . . The organism seeks a perceptually stable environment in a fashion somewhat parallel to that in which it seeks an internally stable environment" (17, p. 466). However, a *perfectly* stable perceptual world would be boring. What we are referring to here is a tentative stability which is ready to give way the next moment. It would, perhaps, be more accurate to say that *some* stability is satisfying since man also gains pleasure from creating new structures. When these goals are achieved the immediately preceding process of perceiving is reinforced, and is more likely to be repeated.

BIOLOGICAL SIGNIFICANCE OF PERCEPTUAL LEARNING

We shall gain a useful perspective if we examine perception and perceptual learning from a biological, evolutionary point of view. An amoeba is capable of receiving light (in some sense of the word "reception") and of reacting. It is even possible to "condition" some unicellular animals to make an avoidance reaction (12). All the way up and down the zoological tree of life animals show some capacity for modifying their reactions to fit their environment, *i.e.*, for learning. Most of the learning resembles what Guthrie (10) calls "negative adaptation" or what Harris (12) calls "habituation." Without being unduly reckless, we can say that only the sensory phase of perception, as we know it in man and other primates, is present in the lowest species. The organism can be made either *more* or *less* receptive through interaction with the environment, but it is extremely limited in the possibilities of perceptual learning.

With increasing complication of organs and functions, evolutionary changes wrought an elaboration on *both* sensory histology and function. As perception grew as a process mediating sense reception with action, the range of potential modification through learning increased. Man became capable of rapidly restructuring his perceptual field. Since the Darwinian philosophy of evolution teaches us that organs and functions emerge that are most "successful" in maintaining a species, we must examine the evolutionary, life-maintaining function of perceptual learning.

Man is bound by his needs and his environment. He is at the mercy of both. What is he to do when he needs to escape a punishing event and his environment will not permit his escape? What is he to do when his stomach cries for food and there is none to eat? By modifying his perceptions he can sometimes escape. This may entail fantasy, or perceptual scotoma. These are paths leading away from experienced pain. By hallucinating food he can *temporarily* satisfy his hunger until he can find food. Perception, in this sense, serves both as a means to realistic con-

tact with reality and also as a delaying mechanism which permits man to delay gratification, to wait. This in turn permits him to carry out long-range projects in which goals are distant.

Perceptual learning enables man to master both his needs and his environment. It permits adaptation to a wider range of possible worlds and a capacity for pure survival unknown to lesser species. Man is equally able to destroy and to create his world.

SUMMARY

Because all authors are biased, including the present ones, it was necessary to present a point of view—to lay our biases out on the table, so to speak. Four important terms had to be examined. These were (*a*) learning, (*b*) perception, (*c*) motivation, and (*d*) reinforcement.

Learning is not just a change in performance. Instead, learning is a process by which the organism functions or performs differently as a result of conditions encountered provided the changes cannot be explained on the basis of maturation, native response tendencies, or temporary states induced by fatigue, drugs, stimulus adaptation, etc. Learning, however, must be linked to behaviors which can be directly observed. Accumulated knowledge tells us that several things influence learning: close contiguity between stimuli and responses; motivation; and reinforcement. But we do not know what factors are necessary and sufficient for learning.

Perception is also unobservable. Some misunderstanding has arisen because perception as a term denotes a process (perceiving) and a product (percepts). As a process, perception is inferred under certain conditions and not under others. A fairly universal requirement is that a physical stimulus be present—although stimulation alone is not sufficient for perception. It is a reasonable requirement that converging operations be carried out before perception is inferred.

Perceptual learning, then, is a change in the status of a logically inferred perceptual state or process as a result of successively applied operations of a learning paradigm. Most of the studies on perceptual learning are on learning to perceive nonveridically.

This situation arises because most learning studies consist of training against preferences and most people perceive veridically.

As a process, perception can best be conceptualized as an instrumental act which structures stimulation. As an act, it can be analyzed into stages, such as a preparatory stage consisting of expectancy and attending, a sensory reception stage, a trial-and-check stage, and a final structuring stage. These stages do not exist as isolated units but merge and intertwine in the process.

A perceptual act can be affected by motivation and reinforcement conditions. Motivation is produced experimentally in two ways—by deprivation and by stimulation operations. Both of these operations do three things. They produce internal stimulation, elicit emotional-affective responses, and produce energization. These internal stimuli function as background stimuli in perception just as external stimuli do and by so functioning influence perception. The affective-emotional responses can function as competing or complementary responses.

Reinforcement of perceptual acts is also possible. According to our analysis of reinforcement, there are many things which serve as reinforcers, including percepts themselves. All reinforcers seem to have in common two aspects: all seem to elicit stimuli and emotional-affective responses which stop the perceptual act and by so doing reinforce the preceding act in a Guthriean sense. Percepts which are clear and stable also reinforce the perceptual act which brought them about by stopping the act.

The biological significance of perceptual learning lies in the flexibility it gives to the perceiving organism. By being adaptive, perceptually, to an environment man increases his likelihood of survival.

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3

Motivation, Reinforcement, and Affect in Perceptual Learning

The question has been raised by Allport (1) as to how motivation can enter into perception. The answer he provides to his own question is basically the same as Bruner's (5) and Postman's (34): that motivation and reinforcement can influence "hypotheses" or "sets" which in turn partially direct the perceptual process. Allport thus rejects the proposition that motivation influences perception *directly*, although he accepts the substantial evidence (11, 25, 28, 29, 32, 36, 37) that motivation does *indirectly* influence perception. But, although the effects of "sets" on perception are well recognized, it is still not clear to us how "sets" themselves enter into perception (48). Allport's solution explains a complex relationship by invoking set, an equally complex and mysterious agent. We might better say that set is a special case

of a general principle: the principle of *relative readiness*. Precisely speaking, the issue at hand is what specific mechanisms or agents are involved.

Our own answers to the problems will be offered here. We shall also provide tentative answers as to how perception can be reinforced, and the limitations of perceptual reinforcement will be spelled out. Our answers to both sets of questions rest heavily upon a consideration of *affect* as the common denominator. We are presenting the basic ingredients of our theory of perceptual learning.

MOTIVATION, AFFECT, AND PERCEPTION

An Overview of Motivation

Let us begin with an analysis of motivation. An organism may be motivated experimentally by either of two operations, these being the "deprivation" and the "stimulation" techniques. In the deprivation technique the individual is deprived of some item that he "needs." An individual is said to need an item if he actively seeks it when it is absent. The more intensely the item is sought for, the greater the need. Or in P. T. Young's frame of reference (46), the more "preferred" an item is, the more it is "needed." If an individual is deprived of exteroceptive stimulation (15), he will actively seek it; or if a child is deprived of a toy, he will hunt for it. For the moment we shall only consider primary needs—*i.e.*, those which are not acquired—since secondary needs are considered to function in essentially the same manner.

When an individual is deprived of items which are necessary for biological survival, certain things take place as a consequence. Internal cues which the individual can discriminate (22, 27) act as triggers to perceptual responses. In addition a complex of visceral-autonomic responses is evoked. We shall refer to the *internal stimuli* produced by deprivation as s_m rather than S_D, as Hull (21) does. The term S_D will be used to refer to discriminative stimuli, after Skinner (38). The complex of *internal responses* which deprivation operations produce will be referred to as r_e (emotional-affective response).

Essentially the same effects are produced by the second technique of presenting certain stimuli which have the property (innate or acquired) of initiating responses. Typically, motivating external *stimuli* (to which we shall refer by the symbol S_M) are what have traditionally been called unconditioned stimuli, although there is no reason for limiting oneself to this class of stimuli. Typical S_M are electric shock, loud buzzers, chalk screech on blackboards, a few hors d'oeuvres before dinner to whet the appetite, and the general class of incentive stimuli. These stimuli are what one would call, in everyday parlance, "affective stimuli." P. T. Young (47) wrote that it does not take a genius to figure out what saccharine solutions, copulation without orgasm, electric shocks, food, and so on had in common—they all aroused affect. In our present terms, these stimuli evoke two things, internal stimuli and emotional-affective responses which are symbolized as s_m and r_e. One can diagrammatically compare the two techniques for motivating an organism as in Figure 2.

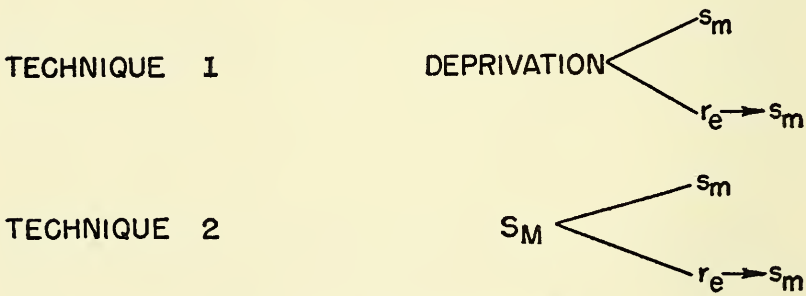

FIGURE 2. *Techniques for motivating an organism.*

Although both techniques produce essentially the same kind of effects, there are fundamental differences. These are largely differences in the suddenness of onset of the s_M and the r_e, though there are also differences in the duration, momentary intensity, and delay of the s_m and the r_e. In the deprivation technique the onset of s_m and r_e is slow and cumulative, and possibilities of adaptation to the s_m are greater. In using this technique, the experimenter usually puts his animals on a deprivation schedule for several days in advance of the experiment proper. This operation

allows the pattern of s_m and r_e to stabilize; or, more properly put, this procedure permits the organism to adapt to the deprivation schedule. In the stimulation technique the onset of the s_m is almost directly contigent upon the onset of the external motivating stimulus S_M, and the r_e is more specific and directed. Adaptation to the s_m is less likely unless the S_M is repeatedly or continuously given.

Some examples can be given for illustration. When a person has gone without food for several hours, he becomes aware of the stimulation (s_m) produced by his stomach contractions (r_e). He is able to discriminate, within limits, how "hungry" he is, and perhaps hungers for specific things (47). In line with our second paradigm, suppose that an individual is given an electric shock to his hand. He immediately perceives his pain (s_m). His emotional-affective responses (r_e) include such responses as speeding up of heartbeat, increased adrenalin flow, increased palmar sweating, and so on. Some of the r_e's occur immediately and some occur with peak intensity *after* a time delay (3, 24). These r_e's in turn produce new s_m which may feed back into the perceptual process still later in time.

Motivational operations also serve as the occasion for intensification effects. That is, these operations seem to energize the individual to carry out both covert and overt activities. We believe that all psychologists recognize this energization aspect of motivation, although the mechanisms by which it is carried out remain in the dark. A careful reading of the Nebraska University symposia (*e.g.*, 25) on motivation reveals that experts in this area are in marked theoretical disagreement as to the precise mechanisms by which this energization arises. There seem to be several possibilities, including physiological need states or physiological deficits, imbalance activating the homeostatic mechanisms of the body, activation of the reticular formation of the brain stem, activation of specific points in the thalamus and elsewhere in the brain stem, energization of the cortical centers by specific activation of the sensory receptors, to mention only a few. Although precise mechanisms remain hypothetical, there is no doubt that motivation must include some energization factor.

Motivation, then, has at least three identifiable aspects: it

involves (*a*) internal stimulation; (*b*) emotional-affective responses which produce subsequent additional stimulation; and (*c*) energization. We turn now to our suggestions as to how each of these aspects of motivation may be linked with perceptual activity.

Internal Stimulation and Affective-Response Aspects

With this orientation in mind let us begin our examination of the possible theoretical relationships between motivation and perception. We approach this problem by first examining perception itself. One of the most basic of all perceptual phenomena studied by experimental psychologists is the influence of surrounding or contextual stimuli and immediately preceding stimuli upon the perception of that given stimulus source in which the experimenter is interested. There are induction effects on perceived brightness of two closely adjacent areas; the perceived loudness of a tone is dependent upon the level of the background noise; perceptual judgments of a series of lifted weights show cumulative effects; and the effects of head tilt interact with the effects of body tilt in perception of the latter, to name only a few examples. There is substantial experimental evidence that perception of a given stimulus source is dependent upon the presence of contextual stimuli, even when different sensory modalities are involved.

According to our conception of motivation, one has a situation which may be diagramed as follows:

$$\begin{array}{ccccccc} & & S_1 & & S_2 & & \\ S_4 & & & & & & S_3 \\ & & & S_p & & & \\ & S_5 & & & & S_m & \\ & & & S_k & & & \end{array}$$

S_p is the perceptual stimulus in which one is interested; S_1, S_2, . . . S_k are contextual stimuli; and s_m are contextual stimuli, for example those occasioned by a motivation technique. Although we speak of these as stimuli, it is not absolutely necessary that the stimulus source be immediately present; it is only necessary that a perceptual trace be present.

As to how these perceptual traces influence perception of the S_p, the most plausible general theories are the adaptation level theory of Helson (16, 17, 18) and the sensori-tonic field theory of Werner and Wapner (43, 44). Indeed, it is not necessary to go outside the orthodox field of perception itself to "explain" some of the effects of motivation on perception. In particular, we refer to the stimulus-producing effects of experimental operations defining motivation. Both Helson and Werner and Wapner assume that stimulations from various receptors are interchangeable, to a large extent, in their effects. Stimulation produced by motivating conditions is nonspecific and serves as "background" stimulation which alters the adaptation level of the organism. Or, in Werner and Wapner's terms, the stimulation produced by motivating conditions enters into the field and intensifies the perceptual traces which are congruent with the prevailing state of motivation. In both theoretical systems, motivation-produced stimulation changes the background level of stimulation and alters foreground stimulation just as the brightness of a surrounding area changes the perceived blackness of a darkened figure by altering figure-ground relationships.

There is still another way that classical perceptual theories can account for part of the effects of motivation upon perception. The mechanism of "set" * has played an important role in perceptual theories, as documented by Allport (1). Sets are induced by several operations. One typical method is to present a sequence of stimuli repeatedly before presenting the crucial, perceptual stimulus. Each of these stimuli lays down a memoric trace; the strength of each of these traces is a function, among other things, of how long ago the original stimulus source was presented. These traces form a context of memoric traces which determine how the final perceptual stimulus will be perceived (33).

Another method of inducing sets is to give instructions to expect "such and such." This operation is functionally different

* Unless we otherwise specify, the term "set" is used to include *Aufgabe* (task sets), *Einstellung* (goal-directed sets), and determining tendencies. In each of these the individual is *directed* or *prepared* to move in one direction rather than another either by pre-established motor preparations or by preliminary cognitive preparations.

in that *no sequence* of *perceptual traces* need be laid down. Its effectiveness in altering the perception of an S_p probably depends upon the instructions arousing memories or sensitizing the subject to differential memories, since these memory traces articulate with incoming perceptual information much in the manner described by Koffka (26), Wallach (42), and Duncker (6). In the Gestalt system a perceptual process is initiated by some stimulus; this *process* immediately begins articulating with memory *traces* on the basis of similarity, prior contiguities of perceptions (which are now memories), and cognitive sets of the individual. The incoming perceptual information will attempt to articulate with the memory traces which are most active at the moment. If instructions do make some specific memory traces momentarily more active than others, then subsequent perceptual processes will be more likely to articulate with the instruction-aroused memories.

With the mechanisms in mind that we have proposed, it is now necessary to consider the various experiments on the effects of motivation upon perception. We shall use our suggested mechanisms as the basis of classification for studies in this area.

There is a neat and systematic series of studies by Gilchrist and Nesberg (11) which are model experiments. In their experiments, subjects were deprived of food or water. "Thirst" groups were given perceptual tests after zero, two, four, six, and eight hours of deprivation. "Hunger" groups were examined after zero, six, and twenty hours of deprivation. The task given subjects was as follows: Pictures of food-related, thirst-related, or neutral objects were shown at a given luminance level, and then the luminance was offset. The subject had to readjust the luminance level to the presented level. The results showed that there was a positive time error for the pictures congruent with the state of deprivation but not for the other pictures. The positive time error increased with longer deprivation of both food and water within the time limit studied. The time error for the control (satiated) group did not change.

The Gilchrist and Nesberg studies are not too difficult to interpret. The symbols are "figural" and the surrounding white area is background. The increase in period of deprivation pro-

duced more internal stimulation which raised the subjects' adaptation level. As a consequence the subjects tended to underset the subsequent illumination, making a positive time error. We would expect an increase in time error with increase in deprivation since need-produced background stimulation is changing.

The classical studies on the effects of food deprivation upon perception are those of Sanford (36, 37). In his first study (36), his subjects reported seeing more and more food and food-related objects in some ambiguous pictures with increasing periods of food deprivation. The ambiguous pictures were pictures which had been so mutilated that it was not certain what they showed. When shown these pictures, Sanford's subjects would say that it was an apple (food object) or that it was a plate (a food-related object). However, in this first study (36) only four hours of food deprivation were studied. In a second study (37), Sanford followed the effects of food deprivation over a twenty-four-hour period. He confirmed the earlier results but also found a waxing and waning of the frequency with which food or food-related objects were reported in accordance with the eating cycle of his adult subjects.

It should be carefully pointed out that Sanford's subjects *did not perceive food* itself; they were always cognizant that they were being shown a mutilated picture and they were only interpreting the picture as *meaning* food. There was always the realistic frame of reference in which the hunger effects were occurring.

Sanford's technique was extended by Levine, Chein, and Murphy (28). In this study, pictures (either in color or in black and white) of three classes of objects (either food objects, ordinary household objects, or geometrical forms) were placed behind a ground-glass screen. Two groups of subjects were run. A control group was tested, shortly after they had eaten, as to how they interpreted what was behind the screen. An experimental group was similarly tested three, six, and nine hours after eating. The results of this study are shown in Figure 3.

The curves reproduced in Figure 3 indicate that subjects tended increasingly to interpret the pictures in terms of food-related objects as the period of food deprivation lengthened. This

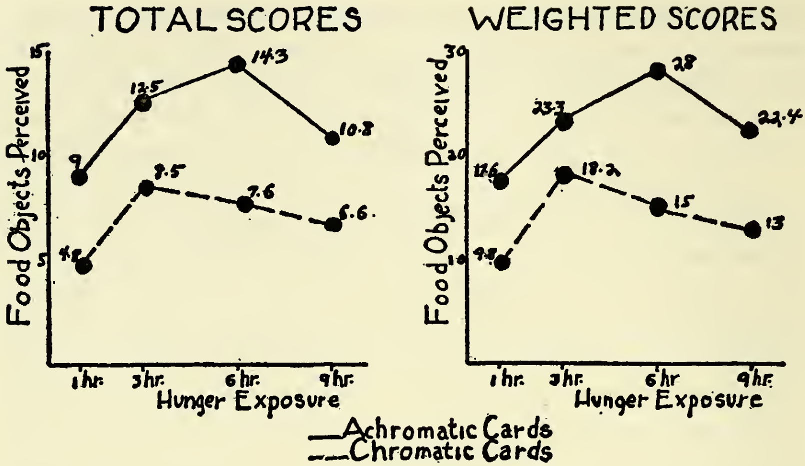

FIGURE 3. *Effects of food deprivation upon the interpretation of colored and black and white pictures in terms of food. The dotted line is for the colored pictures and the solid line is for the black and white pictures.* (From Levine, Chein, and Murphy [28].)

increase does not continue indefinitely, however, and the number of food objects reported decreases after reaching a peak. This peak was at three hours deprivation for colored pictures and at six hours for black and white pictures.

Similar effects were observed by McClelland and Atkinson (29). These investigators projected ambiguous pictures on a screen and subjects reported what they were being shown. The effects of one, four, and sixteen hours of food deprivation were studied. It was found that subjects interpreted the pictures as being pictures of food-related objects, such as knives, forks, spoons, bowls, plates, etc., but not as food items, such as pie or sandwiches. There was an increase in this interpretation with increased food deprivation. It might be added parenthetically that the best effect was found when completely blank slides were projected, in which case imaginal materials were being reported upon.

As an implication of these studies (28, 29, 36, 37) it might be thought that prolonged, semistarvation might produce more

drastic effects upon perception. Such is not the case. Brozek, Guetzkow, and Baldwin (4) observed a group of volunteers over six months in which a bare subsistence level of food was given. Although a number of tests, including projective tests and word association, were given, no prolonged perceptual effect was observed. Indeed, on the basis of this study (4) and the ones (28, 29, 36, 37) in which intervals up to twenty-four hours were studied, we conclude that there is some kind of adaptation of the deprivation-produced stimulation, s_m, with time.

After several hours of water deprivation, and a slightly longer period of food deprivation, the perceptual effects decrease just as general activity does. In disagreement with Hull (22) we do not believe this decrease is due to inanition. An animal is certainly not weaker after so few hours of deprivation. According to O'Kelly at the University of Illinois (personal communication) there is no physiological deficit in water-storing tissues of rats after only thirteen hours of deprivation. The deficit sets in much later. Instead, there is sensory adaptation to the almost continuous presence of the motivation-produced s_m. Figure 4

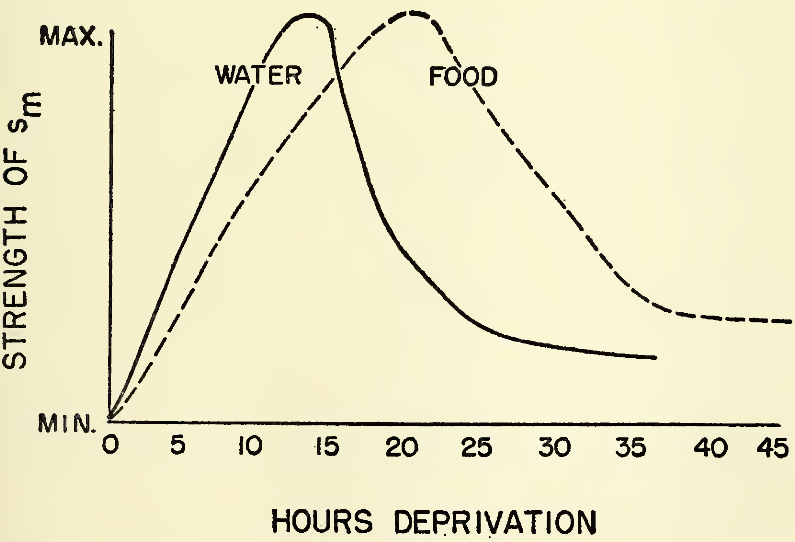

FIGURE 4. *The functional relationship between* s_m *and hours of deprivation. (Hypothetical data.)*

diagrams the functional relationship between s_m and hours of deprivation.

The deprivation operation produces an almost continuous s_m and consequently any conditioning in which the s_m is a *CS* or a discriminative stimulus, S_D, will involve *delayed conditioning* in which the *CS* overlaps with the *UCS*. The stimulation technique of inducing motivation consists most likely of a brief presentation of an S_M, and trace conditioning to an unconditioned response is more likely. These properties imply that the s_m produced by deprivation will become conditioned to a greater variety of behaviors than will the s_m produced by a motivating stimulus.

Let us try to put the foregoing theoretical analysis into simpler language. When we are deprived of food, as is the usual case between breakfast and lunch, the lack of food in our stomach starts our stomach contracting (an emotional-affective response) which in turn produces "signals" (s_m) to us. These signals or motivation-produced stimulation become conditioned stimuli or signs or signals that we will sit down at the table, lift food, put food in our mouths; we will salivate; and we shall perceive food and plates, spoons, bowls, etc. What we do at a table depends upon the discriminations we have made of our hunger (r_e and s_m); if we perceive s_m as nonexistent then we may push our plate away without eating and say "we aren't hungry."

As if the picture were not complicated enough, it is even more complicated when individual differences in reaction to water deprivation are considered according to Klein (25). In Klein's study the subjects were Harvard undergraduates who were chosen on the basis of their performance with the Stroop color-word test. In this test the subject has to read off the color of the letters of words which themselves denote another color, *e.g.*, the word "blue" may be written with green letters. One group of subjects who showed high interference effects and another group who showed little interference effects were chosen; the first group was called the constricted-control group and the second group was called the flexible-control group. Both groups were fed a "dry but attractive meal, consisting of spaghetti with a hot, spicy sauce, heavily garlicked and salted; peanut butter

on salted crackers; dried, very salty herring; and anchovies, topped off by a dessert of salted peanuts and dry chickpeas." The meal was served at noon and all subjects ate at least one serving with some subjects eating several helpings. Nothing was served to drink. Following this, several major tests were given, including a size-estimation task, a peripheral tachistoscopic recognition task, and a word association test. In the size-estimation task subjects had to estimate the size of a disc on which were inscribed symbols of thirst-related objects, *e.g.*, sodas, cokes, highballs, etc. The constricted-control subjects underestimated the size of the discs while the flexible-control subjects overestimated them. There was no over-all effect of need on perceived size when both groups were pooled. In the tachistoscopic peripheral recognition task the subjects fixated a picture of a soda while numbers and letters were peripherally projected at 1/10 second exposure interval for twenty-five trials. The subjects had to identify and locate the peripheral figures. The flexible-control subjects were able to recognize stimuli far from the fixated point while the constricted-control subjects were able to recognize only stimuli near the fixation point. In the word association task subjects free-associated to the stimulus words "dry" and "house" for three minutes. The constricted-control subjects gave only closely related words, *e.g.*, synonyms, while the flexible-control subjects gave more distantly related words, *e.g.*, "Arizona." In short, there was a remarkable difference between the two groups of subjects as to the effects of thirst upon perceptual phenomena.

Individuals display what we prefer to call *affect-control behaviors*. By this term we mean, specifically, behaviors which have the function of channeling affect aroused by needs into socially acceptable directions. The subject who is deprived of water for a number of hours surely knows that the experimenter is not going to deprive him indefinitely of water; indeed, he knows that the experimenter will allow him to drink before there is any real physical danger. Klein comments about this: "After all, Harvard undergraduates are prepared to expect anything from psychologists; our subjects, at least, were resigned to machinations of all sorts, and they knew the deprivation could only be

temporary. Besides, they were paid. While insistent, thirst in this context was never desperate" (25, p. 240).

In addition, some subjects have learned behaviors which partially reduce the final impact of the s_m and the r_e in awareness. We know very little about the behaviors which take the individual "out of the field" of the experiment, but bits of information are accumulating here and there which support the notion that the impact of motivation on perception is not uniform from individual to individual and that the impact of motivation on perception is contingent upon the type and extent of affect-control behaviors within the individual's repertoire prior to the experiment.

This point is worthy of further pursuit. Klein writes: "The muddle in many efforts to define needs in behavior and to understand need as generator and helmsman of behavior may come in large part from neglect of a critical set of variables: regulating structures which modulate, facilitate, inhibit, counteract or otherwise qualify the discharge of need-tension in behavior" (25, p. 224). Klein and his collaborators have made a beginning toward an understanding of regulatory mechanisms which put the "damper" on pressing needs. In effect, the individual is only partially driven by his needs; he is also master of his needs to the extent that he has acquired affect-control behaviors.

Something analogous to the observations of Klein is found elsewhere. Jackson (23) noted a striking difference between subjects who denied being affectively involved with winning and losing money in a perceptual learning experiment and those who admitted being involved, an effect corroborated by Solley and Long (41) and Solley and Engel (40). In the latter study a detailed recording was made of children's behavior in a perceptual learning experiment, and the presence or absence of these extraneous, affect-control behaviors was related to perceptual effects. The children who "smiled," who "shrugged as if being punished didn't make any difference," or who "made faces at the experimenter behind his back" were controlling, *i.e.*, partially reducing the affect aroused by the experiment. Those children who refused to go on, who nearly burst into tears, or who sank into withdrawn silence were not showing adequate affect-control

behavior and their performance was radically different from those who did show affect-control behavior. As Bartlett says: ". . . temperament, interests, and attitudes often direct the course and determine the content of perceiving. The cautious and the rash; the student and the man of affairs; the subject doubting and the same subject confident never perceive alike, though they may all be faced by exactly the same situation, so far as external factors go" (2, p. 33).

There is no doubt that the *sensory* aspects of motivation play an important role in perceiving, but the sensory input supplied by motivation operations is only half the picture. Let us now look at the emotional-affective response, r_e, aspect of motivation, and examine how it can influence or enter into perceiving. Some or all these r_e's "feed back" still other *stimuli* into the perceptual field. We believe this is the basis for an individual's ability to perceive such responses. In fact we believe this may be the basis for qualitative differences in affect. We also believe that this feedback can either facilitate or interfere with an ongoing perceptual act. We know of no quantitative studies in which facilitation of a perceptual act has been explicitly studied, although the operation of this mechanism might be implicitly involved in Murray's study (32) of the perceived maliciousness of faces following a game of "murder" as well as in deprivation studies (4, 10, 25, 28, 29, 36, 37). However, there are studies accumulating (19, 20, 39) which indicate that under some experimental conditions an r_e can interfere with an ongoing perceptual act, as if it were a response which competes with the perceptual act. In essence, this is the Hochberg "interference or disruption hypothesis" which is presented in detail in Chapter 6.

Theoretically, both an s_m and an r_e can interfere with a perceptual act. Whereas feedback from an r_e can interfere with a perceptual act as a competing response, an s_m can interfere with a perceptual act by redirecting the individual's attentional acts. For example, in everyday life we find it difficult to focus our attention upon anything when we have a severe headache or toothache. The pain distracts our attention, and thereby disrupts the normal process of perceiving as well as other cognitive functions.

The Energizing Aspect of Motivation

When an individual is motivated we observe that he appears to be directed differentially toward various alternative goal objects. When he has been deprived of food he searches for food objects, and when he finds them he incorporates them and ceases his search patterns. When a puppy is deprived of his mother's teats he will search for and seek to suck upon something. We further note that the strength of this searching activity varies with the parameters of our motivating operations, *e.g.*, how long we have deprived the animal of food, the intensity of the shock that we administer, how many days the animal has been on the deprivation schedule, or how many shocks we have administered. Direction and strength of behavior vary with our motivational operations. The question at hand is how the direction and strength of perceptual acts can be altered by motivation. Are there any plausible mechanisms through which motivation can differentially energize perceptual processes?

In looking for mechanisms which interrelate perceptual activity with motivational operations we have followed the same course as Gellhorn (7) and Hebb (13, 14). This search for mediating mechanisms involves "tracking" simultaneously the sequence of steps between the reception of a perceptual stimulus and the percept and between the motivation operations and their consequents. If these two sequences conjoin such that one sequence affects the direction and strength of the other sequence, we have some plausible mechanisms for interrelating perceiving and motivation.

Let us begin by examining the "path" extending from reception to perception of a stimulus. Once a sense receptor is stimulated, a chain of stimulation events takes place. The receptor stimulates, "fires," its associated sensory nerve which eventually passes through either the nonthalamic part of the brain stem or the thalamus, or both. At this point in the path, the reticular tracts receive some of the stimulation and the sensory nerve tract continues on to its associated projection area. The reticular tracts in the brain stem and thalamus are of primary importance

to our theorizing since they serve to arouse the entire cortex and form the basis of what Hebb (13) calls a "generalized drive state."

Let us now try to track the path of the effects of motivation operations. Assuredly we can do no more than sketch the possible routes, since there are so many. We have noted that motivation operations, namely, the deprivation technique and the motivating stimulus technique, both arouse internal stimuli and emotional-affective responses (which in turn produce further internal stimuli). These internal stimuli consist of enteroceptive and proprioceptive stimulation; and the emotional-affective responses may also discharge hormones into the blood system. All of these sources of stimulation, including hormonal changes, ascend to stimulate the reticular system of the brain stem. From this point further ascending and lateral tracts control the over-all arousal of the cortex as well as regulating sensitization of specialized sensory projection areas. This tracking of the effects of motivation operations leads us to conclude that motivation must have both a general and a specific energetic effect upon perception.

There *are*, then, mechanisms through which motivation can enter into the perceptual process. In fact, according to a recent review by Samuels (35) of the literature on reticular mechanisms we cannot underestimate the influence of motivation upon perceptual processes. In her review, which we have found extremely useful, Samuels brings out several pertinent points. She writes: "First, it is apparent that the cortical arousal responses induced by stimulation of the brain stem reticular system are independent of the specific sensory pathways. . . . Second, the arrival of specific sensory impulses in the cortex is not, in the absence of non-specific reticular activity, a sufficient condition for the conscious perception of these impulses" (35, p. 2). As Gellhorn (7) has pointed out, the classical afferent nervous system may provide the content of perception but it does not provide consciousness; instead, the activity of the nonspecific reticular system, which is activated by interoceptive, proprioceptive, nociceptive, and hormonal changes, seems to govern the processes of perception in awareness. The arousal of the nonspecific retic-

ular system through motivational operations sets the stage for the facilitation, selection, or inhibition of sensory input *before* the percept is ever structured in awareness.

Motivation raises or lowers the level of consciousness with which perceptual acts are carried out; it functions to guide the selectivity that we observe in perception; it serves both a facilitative and an inhibitory function. In short, motivation does govern the direction and strength of perceptual acts; indeed, without motivation effects it is doubtful that we would perceive at all.

REINFORCEMENT OF A PERCEPTUAL ACT

There is a tentativeness in perception which is largely overlooked by adults in the rapid process of perceiving daily events. Woodworth (45) was referring to this tentativeness when he spoke of "temporary registrations" which shift with each change in the environment, and to Woodworth reinforcement made these temporary, tentative, perceptual acts more permanent. This is our beginning point. One of us (G.M.) has written elsewhere: "Initially there are *unstable* perceptual responses which permit modifications . . . it is by virtue of the momentary instability of the perceptual system that the reward can exert its influence" (31, p. 5). We have already discussed how we are going to use the concept of reinforcement, briefly, in the weak sense (30) of the Guthrie-Skinner-Estes school of thought. What is reinforcing, in a positive or negative way, is to be determined empirically. We have suggested that all stimuli or operations which arouse affect, *e.g.*, food, water, electric shock, monetary gain, approval from a respected person, return to home cage, copulation (even without completion), saccharine solutions, etc., constitute the largest class of reinforcers, although we recognize that drive-reducers, drive-intensifiers (as onset of shock), and perhaps the achievement of perceptual stability itself can function as reinforcement.

In comparing an overt response act, such as pressing down a bar in a Skinner box, with a perceptual act, such as seeing a Necker Cube going from right to left, we have pointed out that the distinguishing characteristic of an "act" is that there is a

change or restructuring of the environment; in the former case the physical environment is altered and in the latter case the perceptual field is restructured. The only difference lies in (*a*) the strong limitations imposed upon the class of available perceptual acts by the characteristics of the received stimulus and (*b*) the fact that the perceptual act terminates "internally" and is unobservable except by the perceiver himself. This last characteristic of a perceptual act means that we cannot "locate" the completion of the perceptual act spatially, although we can approximately locate its completion temporally. Experimentally, we know that the perceptual act is completed some time between the presentation of a stimulus source and the emission of an overt response which is used to infer something about the percept; the major experimental problem in the experimental reinforcement of a perceptual act is how best to estimate when to administer a reinforcement. If the reinforcer is administered *during* the perceptual act, it is most likely to interfere with the consolidation of traces; if it is administered too long after the perceptual consolidation, it is more likely to influence memories rather than the perceptual act.

The operations for estimating the time between the presentation of the stimulus and completion of a perceptual act need to be spelled out, at least in suggestive form. The best technique that we have observed is to use trained observers. If the onset of the perceptual stimulus starts a standard electric timer or a Hunter decade counter and the observer presses a key to stop the timer as soon as he perceives—*e.g.*, has differentiated figure from ground—then the elapsed time consists of (*a*) time required for the perceptual act and (*b*) reaction time. Though obviously contaminated by reaction time, the elapsed time gives a fairly good *estimate* of time required for the perceptual act. This time will vary as a function of simplicity (or complexity) of the perceptual stimulus, degree of differential brightness between figure and ground, number of cues to be assimilated, number of sensory modalities involved, and amount of previous experience. The second method which we find useful is more laborious and also more empirical. The experimenter can vary the time between perceptual stimulus and the reinforcer. As this interval changes,

one gets differing results in perceptual learning just as one gets different results in trace conditioning as the *CS-US* interval is varied. By giving a reinforcement stimulus at varying time intervals after reception of the perceptual stimulus and empirically noting the effects upon the perception, an experimenter can empirically determine the optimal time for introducing the reinforcer. This technique is more fully presented, in Chapter 6, as a device for estimating the time required for a perceptual act.

Most reinforcement stimuli or operations function like motivating operations. Diagrammatically, $S_{Rein} \begin{matrix} \nearrow s_{rein} \\ \searrow r_e \end{matrix}$ just as we outlined for a motivation operation. (As a reminder, the capital letter as in *Rein* refers to stimulus situation as viewed objectively; the same term beginning with a small letter refers to some sort of repercussion or internal stimulation inside the organism.) The r_e associated with a S_{Rein} reinforces overt responses and perceptual acts by stopping the last occurring response or act. This is a version of Guthriean (12) reinforcement. A food pellet does *not* reduce drive to any sizable extent, but it does take a rat away from the bar in a Skinner box and by so doing stops the bar-pressing response. The s_{rein} (internal stimulation associated with the intake of the food) is perceptually structured (it has perceptual attributes) and it motivates the animal to act again. Not all reinforcement stimuli or operations function this way, but the large class of so-called incentive stimuli do.

A word of caution is called for. The old Thorndikian principle of practice as a basic means of learning must not be overlooked. Even with no visible reinforcement or knowledge of results, behavior can stabilize around some norm. This is certainly some kind of learning. In the field of perceptual learning this principle is most in evidence in studies of "habituation" and other long-range nonassociative shifts in sensory reactivity. Learning by practice is also very much in evidence in the development of "literal" perception which James J. and Eleanor Gibson (8, 9, 10) have so brilliantly described. External reinforcement is not necessary for perceptual learning; sufficient, yes, but necessary, no. Reinforcement can speed up or slow down,

i.e., affect the rate of perceptual learning, and it can determine *which* perceptual structures will become dominant. However, it is not absolutely crucial. "Needs" are far more crucial than are reinforcements in that motivation produces practice and also supplies internal stimuli to the perceptual context. It is conceivable that perceptual learning would take place without any external reinforcement but it is doubtful that it would ever occur without motivation. In a very real sense, the external environment supplies checks on both the initiation and the confirmation or rejection of perceiving and percepts.

This brief presentation of how a perceptual act can be reinforced, positively or negatively, by reinforcement stimuli or operations and by practice is admittedly abstract. It overlooks the manifold details necessary for precise experimentation. For that reason, we shall take up, in succeeding chapters, specific analyses of the roles of (*a*) rewards, (*b*) practice, and (*c*) punishment in perceptual learning.

SUMMARY

There are a number of studies, such as those by Sanford, Levine, Chein, and Murphy, McClelland and Atkinson, and Gilchrist and Nesberg, which demonstrate that motivation does influence perception. The problem of how this occurs was analyzed. It was argued that experimental operations, which provide the occasion for motivation, do two things: they produce internal stimulation as well as initiate emotional-affective responses. These internal stimulations function as background stimulation for perception and as such alter the adaptation level of the perceptual field. These internal stimuli also initiate sets which in turn direct the perceptual process. The emotional-affective responses which are aroused by motivation operations also influence the perceptual act by either intensifying or interfering with it.

It was also contended that if a reinforcement stimulus is given to an individual immediately following the completion of a perceptual act, then the probability of that perceptual act occurring again in the presence of the perceptual stimulus will be altered. Reinforcement stimuli reinforce perceptual acts by stopping the

act and preserving it. We believe it does this by arousing emotional-affective responses which preserve the perceptual act. However, perceptual acts are also reinforced by percepts themselves and external reinforcers are not absolutely necessary for perceptual learning.

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Autism" and 'erception

The concept of "autism" in the cognitive life of individuals has implications for the fields of clinical and experimental psychology. Although the evidence from clinical cases is more dramatic than the evidence from experimental research, the two sets of data are in no wise contradictory. Each tends to supplement the other, and we can understand the concept of "autism" only by looking at what clinicians have had to report and at the results of experiments in the laboratory. Our approach in this book has been to rely heavily upon evidence obtained in the laboratory. But there are glaring inadequacies in almost all experimental studies; *e.g.*, the drives, motivations, rewards, affects, etc., that we can manipulate in the laboratory are in general far

less intense and varied than the ones in everyday life. In general, this chapter is an attempt to integrate clinical and experimental conceptions of autism. We shall not attempt to cover the manifold related issues, such as how autism fits into a fuller conception of personality or the role autism plays in a general theory of cognitive functioning. We are concerned mainly with directly examining its role in perception and perceptual learning.

There is instructive value in making such a direct examination. The products of learning in certain paradigms often reveal a great deal about the nature of learning, for an autistic percept may carry with it the hallmark of its genesis. A careful analysis of autistic perception can tell us much about the role of motivation in perception, how it enters into the perceptual process, and the limitations of its effects. It can also tell us much about the developmental aspects of perceptual change and how veridical percepts emerge as autistic percepts are extinguished or repressed. Indeed, one of our chief purposes for concentrating on the learning of autistic percepts is to study effective methods of *undoing* such effects in order to achieve even greater veridicalness in perception.

There are two other important consequences of an analysis of autism. One effect would be to integrate experimental and clinical knowledge on a limited front, so that experimental results of perceptual learning studies can be more directly translated into the realm of clinical application. Another effect would be to cast more light upon the biological significance of perceptual learning, and particularly upon the biological significance of motivated perception.

EXPERIMENTAL CONCEPTIONS

In order to carry out research on motivation and perception it is necessary to develop some kind of definition of autism. Such definitions are to be found in several experimental papers, and we refer to these as experimental conceptions of autism and autistic perception. In this literature one sometimes reads that "this result could be expected on the basis of 'autism'" or "autism theory would predict such and such." But what is autism

in perception? Is it to be construed as some magical force or as a "fudge factor" in its ability to fill the hiatus of our ignorance? It could be, but the concept is not necessarily confused—if it is carefully and scrupulously used. We need to clarify what it can and what it cannot mean scientifically. A review of several writers' opinions on autism, especially with regard to perception, is useful for this purpose. From these opinions we can proceed to seek out the crucial and stable points of agreement, perhaps adding new aspects, and thus *construct* a workable definition of autistic perception.

The most commonly quoted definition is that of Chein (27): "Autism is the movement of cognitive processes in the direction of need satisfaction." The term "cognitive processes" was understood to include memory, thinking, imagination, and perception. According to this definition, an autistic percept would be one so structured, organized, or emphasized that it satisfied the needs of the individual. This conception ran full steam into a host of difficulties. Rapaport makes the most cogent criticism. He writes: "The shortcoming of the definition is that in the long run all human behavior and thought subserves and is directed toward satisfaction, and the distinctive character of autistic thinking is probably its short-circuit course toward satisfaction" (40, p. 399).

Rapaport is correct in that it is erroneous to speak of movement in the direction of need satisfaction since all behavior and cognition can be shown, at least logically, to move in such a direction *in the long run*. One must qualify Chein's definition at least by placing the word "immediate" before need satisfaction, and one must be very careful to consider what need satisfactions are occurring and whether they are realistically related to the situation one is in or not. Worse still, this definition of autism refers clearly to the "movement" or change, and stresses *neither the causes* (antecedent events) *nor the products* (consequent structures). It succeeds only as a first attempt to define autism in such a way that experiments can be performed to test its implications.

It should not be concluded that Chein's definition of autism was "bad." Much good can come from an inadequate definition.

In this case, it served as a springboard from which various investigators (*e.g.*, 37, 44, 45, 46) developed research ideas. It has outlived its usefulness, however, and a more dynamic conception is needed.

Recently, Helson advanced some cogent thoughts on the problem at hand. He equates proneness to autism with excessive susceptibility to inner determinants of perception. According to Helson, this excessive susceptibility can arise from at least four sources—"memories, residual traces from previously experienced dangers, excessive anticipatory reactions before danger actually threatens, or the result of magnified feed-back mechanisms wherein awareness of one's own bodily processes figure prominently" (23, p. 1). There are some distinct advantages in this approach. It stresses, properly, the concept of perception as a resultant of inner and outer determinants, between the what-is-inside and the what-is-outside. If there is a good psychophysical correspondence between the individual's reports and the potentiality of his environment, then the individual may be said to be perceiving his environment veridically (18). Such an act is not static: at one moment the inner determinants are dominant and in the next the outer determinants carry the most weight. It is only when the general trend is for the inner determinants to carry the most weight that the organism is said to be perceiving autistically.

Experimentally, one maximizes the possibility of autism by reducing the influence of the outer determinants. This is usually accomplished by presenting an impoverished stimulus environment so that it is difficult to structure any percept on the basis of environmental information alone. Or the environment may be made overly rich so that many, equally good percepts are possible, and the individual is faced with ambiguity of structure. Or the outer world may be made so uninteresting, so dull, as in sensory deprivation studies (3, 25, 28), as to lose the compellingness of attention. In most studies on perceptual learning there is both a reduction in the potential influence of the outer world and an increase in the intensity of the inner determinants, although it is not necessary to manipulate both factors simultaneously.

As Helson says, something as simple as memory can override outer determinants causing subjects to perceive nonveridically. There is a simple experiment by Duncker (10) which beautifully illustrates this point. In his study, observers had to match the color of a drawing of a donkey and of a leaf by means of a color wheel. However, in this case the donkey was painted green and the leaf was painted gray. The observers set the color wheel closer to gray for the donkey and closer to green for the leaf than the immediate veridical colors demanded. The subjects were comparing the colors on the color wheel both with the immediately present colors and with the memory traces of previously seen donkeys and leaves, and the result was a compromise.

Of great interest to us are Helson's (23) last three suggested determinants of autism. Two of these—(*a*) residual traces from previously experienced dangers, and (*b*) excessive anticipatory reactions before danger actually threatens—are clearly relevant for perceptual learning experiments in which noxious, punishing stimuli are associated with perceptual materials. The first of these two determinants functions by the accumulation of perceptual traces through learning and consequently the formation of an adaptation level (21, 22) or frame of reference. The second determinant functions by the establishment of strong response sets to escape, to avoid, or to brace against the onset of noxious stimulation. Both of these determinants will be discussed again in Chapter 6.

The last determinant—magnified feedback of one's own bodily processes—is also very significant. Helson would require that the individual become *aware* of this feedback. An example of this mechanism would be the individual who has a severe stomach ache whenever he eats strawberries, and who becomes conditioned to having a stomach ache upon just seeing the berries. The pain and nausea which stems from the internal feedback can disrupt the perceiving process and make cranberries appear to be strawberries. This is an oversimplified example, and we will return to this mechanism in much more detail in the chapter on feedback.

An evaluation of Helson's definition is difficult, mostly be-

cause little work has been directly associated with it. The definition does appear to have enormous potentiality for research, however, since it stresses determinants which can be easily linked to experimental operations and to Helson's adaptation-level theory of perception (21, 22).

One of us has attempted a comprehensive treatment of this problem: "Needs determine how the incoming energies are to be put into structural form. Perception, then, is not something that is first registered objectively, then 'distorted.' Rather, as the need pattern shifts, the stage is set, minute by minute, for quasi-automatic structure-giving tendencies that make the percept suit the need. The need pattern predisposes to one rather than another manner of anchoring the percept to one's needs. *Needs keep ahead of percepts*" (29, pp. 377–378). Needs of a moment prepare the individual for the perception of the next moment.

The importance of this point is often overlooked. For example, both Allport (2) and Postman (36) criticize the so-called "directed state" theory of perception as not including "set" as an important variable. Yet in the quotation just cited (29) it is noted that needs provide predispositions or sets which determine how stimulus information will be structured. Allport and Postman are correct in accusing the directive-state theorists of not considering the effects of set *carefully enough.* Set (or a still broader concept, that of readiness [cf. p. 37]) is an important variable; the question is where to look for its beginning. Do not motivations originate a vast number of expectancies and sets and, by so doing, set the state for autistic perception? Autistic perception does not arise randomly but finds its antecedent "cause"— if you will— in the sets provided by needs.

But needs are just the first requisite for perceptual learning and autism. Three stages in the development of autism are noted in the cited passage. First, drive satisfactions or frustrations yield affects that are fused with cognitive dispositions, as a child fuses wishes with reality. Secondly, the cognitive structure becomes dominant in the process, and primitive meanings of acceptance (good) and rejection (bad) are assigned. Thirdly, the affective components are integrated or crystallized with the cognitive elements into a whole of experience. This final stage represents

autism. "Indeed, it is precisely when the affective ingredients markedly distort the cognitive picture of reality, so that the observer is markedly misled by the distortion, that true autism appears" (29, p. 366). A quality of this last stage is a *lack of awareness* that reality is being distorted. By linking the concept of autism to the concept of canalization (29), a long-range developmental growth of autistic factors is emphasized.

Two men are responsible, more than any others, for the massive knowledge that has accumulated on the developmental aspects of cognitive growth. These two are Jean Piaget and Heinz Werner. Both have contributed heavily to knowledge of the maturational aspect of perception and the role autism plays in long-term growth patterns. Their contributions must be emphasized.

Piaget (30, 31, 32, 33, 34, 35) provides us with a great deal of useful information. In *The Construction of Reality in the Child* (35) Piaget outlines a theoretical sequence of mental development. First, there is a stage in which the child makes no distinction between himself and his experiences. Close on the heels of this stage is a period in which the "I" and the "not-I" are distinguished, but the child's concepts of causation are based on the principle of "when I intend an object in perception I cause it to happen." In this stage, primitive assimilatory schemata are formed, based on simple circular reactions: perceptions, self action, object action, new perception. The infant perceives a hanging rattle, he strikes it, it moves, he perceives that it moves, and the infant cognizes the "cause" of the rattle's action as his original perception of it. Shortly, the infant generalizes the "causality" principle to the object itself such that the object is "alive." This is the stage in which primitive magical beliefs evolve. In later stages of development the child becomes more aware of his own actions and differentiates events caused by his own actions from those events caused by outside sources. This theoretical sequence has not been proved by Piaget—or, for that matter, by anyone else. It is purely hypothetical at present.

This development of awareness of self is crucial. Elsewhere, in *The Child's Conception of Physical Causality*, Piaget has this to say:

> Let us examine these processes more closely. In order to be objective, one must have become conscious of one's "I." Objective knowledge can only be conceived in relation to subjective, and a mind that was ignorant of itself would inevitably tend to put into things its own pre-notions and prejudices, whether in the domain of reasoning, of immediate judgment, or even of perception. An objective intelligence in no way escapes from this law, but, being conscious of its own "I," it will be able to say what, roughly, is fact and what is interpretation (32, pp. 241–242).

Speaking more directly about autism, Piaget wrote:

> Autism . . . [is] thought in which truth is confused with desire. To every desire corresponds immediately an image or illusion which transforms this desire into reality, thanks to a sort of pseudo-hallucination or play. No objective observation or reasoning is possible: there is only a perceptual play which transforms perceptions and creates situations in accordance with subject's pleasure. From the ontological viewpoint, what corresponds to this manner of thinking is primitive *psychological causality*, probably in a form that implies *magic* proper: The belief that any desire whatsoever can influence objects, the belief in the obedience of external things. Magic and autism are therefore two different sides of one and the same phenomenon—that confusion between the self and the world which destroys both logical truth and objective existence (32, pp. 302–303).

Though Piaget does not expressly say so, we can easily deduce that autism always underlies logical thinking. This follows from his conception of the stages of development in which the realistic schemata of space and time and objects are interwoven with and *built upon* the primitive, assimilatory schemata in which the wish automatically "causes" the percept.

Piaget provides us with countless delightful illustrations of "autism" in children's thinking. He writes:

> The first manifestation of child realism is what we might call the confusion of psychic and physical. . . . Small children

> have no notion of thought as distinct from material activity. . . . We asked sixty children between the ages of four and twelve what one thinks with, and whether one can see or touch thought. . . . All of the children under about seven answered, like Stern's little girl, "we think with our mouths." "As for animals," said a little boy of six, "they think with their mouths, too, all except the horse, and he thinks with his ears, because he hears when you speak to him but he doesn't talk himself. . . ."
>
> During the next state, which lasts from about seven to ten or eleven, grown-up influence is felt. The child answers that we think with our heads, because that is the current social belief. But, under these words the child's conception remains spontaneous and in complete continuity with the answers of the first stage. We think with "a little voice inside our heads," says a boy of nine, with "a little mouth" (33, pp. 377–378).

Here we see the gradual emergence of veridical cognition, through the motivation of social pressure, from autistic cognition. There is no sharp break where one manner of functioning ends and the other begins.

One observes very similar ideas in Werner's (47) description of the process of perceptual development. The young infant functions *syncretically*. That is, there is a fusion of several processes, notably affective, perceptual, cognitive, sensory, and motor. It is almost impossible to study any one of these processes without also involving the other. In Werner's own words: "It is characteristic of primitive mental life that it reveals a relatively limited differentiation of object and subject, of perception and pure feeling, of idea and action, etc." (p. 59).

In addition, the young child does not perceive things independently of one another. "Things do not stand out there, discrete and fixed in meaning with respect to the cognitive subject. They are intrinsically formed by the psychophysical organization of which they constitute an integral part, by the whole vital motor-affective situation" (p. 59). The reader will note that Werner makes a great deal more use of motor activity in his concepts of development than does Piaget. In fact, Werner agrees

emphatically with Hebb that "the coordination of physical movement and sensory impressions is basic for primary form perception" (p. 60). Perception and activity are fused with one another, although the individual may never be aware of the motor component.

Perception, in the early years of life, is further characterized by being vague, yet concrete, and extremely labile or susceptible to change. The constancies of perception which supply structure and articulation to the perceived world have not been developed and the child often perceives in an "animistic" manner. Werner theorizes about this as follows:

> The high degree of unity between subject and object mediated by the motor-affective reactivity of the organism results in a dynamic, rather than static, apprehension of things. Things as constituent elements of a dynamic event must necessarily be dynamic in nature (p. 67).
>
> Such dynamization of things based on the fact that the objects are predominantly understood through the motor and affective attitude of the subject may lead to a particular type of perception. Things perceived in this way may appear "animate" and, even though actually lifeless, seem to express some inner form of life (p. 69).

The child does not permanently function in this syncretic fashion but gradually separates the various psychological functions of feeling, perception, and activity. Within perception itself discrimination of things and the attributes of things develop, the result being a differentiation of subjective and objective factors, of feelings and percepts, and of percepts and actions. "Animism" also extinguishes, although residual traces are to be found in "physiognomic perception" in adults.

Perhaps this summary of Werner's ideas about autism has been too brief. Perhaps there have been too few experimentally oriented concepts of autism presented here; there are a number of others, such as those of Charlotte Buehler and Koffka, which we could have presented. Our only excuse is that it is better to present a sample of the diverse opinions about autism than to try to cite all possible opinions. Our purpose—for this book—is only

to look at autism, its nature and functioning, so as to obtain a clearer conception of the roles which motivation, learning, and maturation play in perceptual learning.

It is now necessary to contrast experimentally oriented with clinically oriented concepts of autism. Fenichel (11) has briefly contrasted the two and finds considerable differences. Such differences can help to complete the picture of autism that we are striving for.

THE CLINICAL CONCEPTION OF AUTISM

The richest ideas about autism, in the most general sense, are those based upon the observation of patients. Although such materials are not repeatable in the sense of laboratory repetition, they are based upon countless vivid, independent observations which represent stronger effects than can probably ever be produced in the laboratory. The motivations, drives, and experiences which produce the "autistic effects" are more intense than almost anything we can duplicate in our experiments. In a real sense, life is a better experiment than anything we copy. For a penetrating picture of autism we can turn to the writings of clinicians. Whereas they paint their portraits with the bold strokes of life, the experimentalist must be satisfied with finer, more meticulous, but more incomplete techniques.

The core of the psychoanalytic conception of autism is the Freud-Fechner (1, 14) principle of stability. Alexander describes these ideas as follows:

> The psychoanalytic theory of the ego is that its function is to implement the principle of stability. The ego is the governing head of the organism and is doubly perceptive. By internal sensory perceptions it registers internal disturbances of the physio-chemical equilibrium, perceiving them as needs and sensations. Through external sensory perceptions it registers the environmental conditions upon which the gratification of its need depends. It has also *integrative* and *executive* functions. It is the center of motor control, and by confronting its *internal* with its *external perceptions* it can integrate them and gratify subjective needs as much as possible under

> given external conditions (coordinated goal-directed voluntary behavior) (1, p. 36).

This basic idea parallels roughly Helson's (23) conception of perception as a resultant of inner and outer determinants, although Alexander is stressing internal and external perceptions instead of internal and external determinants of perception. It is the constant attempt to integrate internal and external aspects of perception in an attempt to gratify subjectively felt needs that serves as a basis for the development and operation of autism. This fundamental principle is not sufficient in and of itself to understand autism, but it does state an important dynamic.

In "Formulations Regarding the Two Principles in Mental Functioning," Freud brings out the process by which the *Lust-Unlust* (Pleasure-Pain) principle of mental functioning becomes superseded by the reality principle, although reality is never fully achieved in mental functioning. Freud wrote:

> There is a general tendency of our mental apparatus . . . which seems to find expression in the tenacity with which we hold on to the sources of pleasure at our disposal, and in the difficulty with which we renounce them. . . . The supersession of the pleasure-principle by the reality-principle with all the mental consequences of this . . . is not in reality accomplished all at once; nor does it take place simultaneously along the whole line (14, Vol. IV, p. 16).

There is always some aspect of the drive system, namely bound-cathexes, which sticks to percepts and from which the out-there reality can never be fully discriminated. It is this feature of ideas and percepts that underlies Rapaport's conception of percepts as drive-representations (40) which are capable of short-term gratification, though perhaps not of long-range gratification, of needs. The more permanent this means of gratification becomes the more autistic the individual is said to be.

Schilder (43) has developed a systematic conception, which goes far beyond the simple Freud-Fechner principle. He writes:

> Wishes are thus capable not only of arousing definite images and thoughts, but also of giving them reality-value and per-

> ception-character. . . . The transformation of images into percepts appears dynamically as the consequence of greater affective libido-cathexis (p. 207).

The attachment of drives to percepts is considered crucial by Schilder, for he further writes:

> Alterations of drive-attitudes are the pre-requisite for the transformation of images into percepts (p. 207) [and] the form in which the perceptual world appears to us depends on drives, but . . . a part of these drive-processes is already structured into organization (p. 206). [Further], the affective mechanisms . . . (particularly ego-projection, and projection in general) do continuously intervene, modifying the basic process of simple perception; and, moreover, . . . even *correct cognitions* [ITALICS OURS] may come about in this way. When my affectivity is correctly attuned, I will project into others only those portions in my own experience which by their nature objectively justify being projected (pp. 327–328).

Schilder elsewhere (42) concluded that individuals go through a developmental or learning process in cognition and perception. The stages are first indefinite percepts followed by a period in which these indefinite percepts develop into more definite percepts. During the early phase of this development, perception and affect are inextricably linked. Although the individual may achieve more and more reality orientation, he never completely frees himself; his thinking and perception are always vulnerable to the pleasure-pain principle and the early affective ties.

The unique aspects of Schilder's conception stand out. First, there is the idea that wishes, drive attitudes, and needs are necessary for the most elementary transformation of images into percepts. Schilder's implication that drives are necessary for the conscious formation (perception) of sensory data is not far from the newer ideas about the effects of the extra-reticular system, with its accompanying pleasure-pain dynamics, on consciousness of sensory inputs (see Gellhorn, 17). Further, Schilder is clearly stating that an aspect of drives (probably drive derivatives) is always linked to percepts; that no percept exists without an ac-

companying association with drive derivatives. These ideas, stated in 1923, sound remarkably similar to some of the ideas of the "new look" psychologists. Thirdly, Schilder's contention that ego-projection and projection in general is an *affective mechanism* which constantly modifies basic perception is the very heart of modern conceptions of projective tests (15, 39). Frank (16) says:

> If it were not liable to gross misunderstanding, the personality process might be regarded as a sort of rubber stamp which the individual *imposes* [ITALICS OURS] upon every situation by which . . . he necessarily ignores or subordinates many aspects of the situation that for him are irrelevant and meaningless and selectively reacts to those aspects that are personally significant (p. 392). [He also says] We may emphasize then that personality is approachable as a *process* or operation of an individual who organizes experience and reacts affectively to situations (p. 392).

Fourthly, Schilder is unique in pointing out how the same mechanisms which can lead to such bizarre events as hallucinations, illusions, and distorted perceptions are also responsible for veridical perception. It is easy to see how our needs to meet reality impel us to achieve veridicality and that perceiving veridically can be just as affective (pleasant or unpleasant) as perceiving nonveridically.

Bleuler (6) described autism as follows:

> One of the most important symptoms of schizophrenia is the preponderance of inner life with an active turning-away from the external world. The most severe cases withdraw completely and live in a dream world; the milder cases withdraw to a lesser degree. I call this symptom *autism* (p. 399).

We note here a resemblance between Bleuler's and Helson's concepts in that autism is basically a preponderance of inner life with its multitudinous stresses and strains. But autism was more than just this to Bleuler, for he wrote:

> Autistic thinking has its own direction. It mirrors the fulfillment of wishes and strivings, thinks away obstacles, con-

> ceives of impossibilities as possible, and of goals as attained. It does so by facilitating those associations which correspond to the striving, and by inhibiting those which contradict it, that is by mechanisms familiar to us as influences of affects . . . there is no sharp borderline between autistic and ordinary thinking: autistic, that is affective, tendencies easily penetrate the latter . . . even normal persons will only too often draw false conclusions to suit their mood and inclination (6, pp. 404–405).

Bleuler clearly regards affect as the subjective aspect of motivation and drive, and views affect as central to the facilitation and inhibition of percepts. For a fuller account of the roles of affect and the function of primary process mechanisms in autism the reader is referred to Bleuler's other works (4, 5) and to Rapaport's comments on Bleuler (40, Chaps. 20 and 21).

Elsewhere (4, 5), Bleuler discusses what he considers the two most important requirements for production of autism. These are (*a*) extremely strong affect which cannot be delayed and (*b*) an environment which does not provide enough sensory information. When the environment provides fragmentary information—as in the case of what Freud called the "day-residues" which enter into dream construction—then affective impulses and other inner determinants clearly balance perception in the direction of wishful organization, even as in dreams. On the other hand, Bleuler also points out (7) that "exact thinking" or realistic cognition functioning can be achieved only by (*a*) becoming aware of the drive aspects of one's own perceptions and/or (*b*) acquiring more sensory information so that outer determinants gain more weight.

Bleuler (6) provides his own summary: He wrote:

> Autistic thinking is independent of logical rules; it is directed by affective needs.
>
> It is most obvious in dementia praecox and in the dream, next in mythology and superstition, and finally in the day-dreams of hysterics and normals and in poetry.
>
> Autistic thinking can use entirely illogical material; clang associations and incidental connections of any percepts or

> ideas may replace logical associations. Concepts incompletely thought through, false identifications, condensations, displacements, symbols treated as realities, and other similar abnormal thoughts constitute part of the material which it uses. Normal material and trains of thought are by no means shunned but used side by side with the abnormal. . . .
>
> Autistic thinking is directed by strivings which disregard logic and reality. The affects that underlie strivings, facilitate associations that favor them and inhibit opposing ones according to well-known laws. [Here Bleuler is referring to the *Lust-Unlust* principle of mental functioning.]
>
> It is our tendency to avoid pain not only when inflicted from without but also when elicited by mere ideas. The success of autistic thinking consists mainly in the creation of pleasant ideas and in the suppression of unpleasant ones. To think of wishes as fulfilled is one of the main activities of autism.
>
> Autistic thinking, just like logical thinking, can be either conscious or unconscious (pp. 435–437).

In a real sense, the problem of awareness of the autistic perception or idea is not the most important one. A more crucial problem is whether the individual is aware of (*a*) the discrepancy between his perception and the veridical input and (*b*) the relationship between his subjective experiences of affect and his percepts. So long as the individual is never aware of either of these relationships, he will "accept" the autistic product as "real" and will act accordingly, often flying in the face of reality and suffering as a consequence.

Perhaps it is unwise to quote from artists in writing a scientific book, but frequently artists, and especially writers, provide quick and penetrating insights into the nature of man's autism. There is a beautiful passage in Lewis Carroll's *Through the Looking Glass* which illustrates this:

> "When *I* use a word," Humpty Dumpty said in rather a scornful tone, "it means just what I choose it to mean—neither more nor less."

> "The question is," said Alice, "whether you *can* make words mean so many different things."
>
> "The question is," said Humpty Dumpty, "which is to be master—that's all."

A word is not a word is not a word, to pun on Gertrude Stein, unless the user *gives* meaning to it. A percept is not a percept unless the perceiver provides it with feeling and substance. Autism is not a passive process nor does it idly arise; rather, it stems from an active reaching out toward the world of the senses, and a struggle to be master of what one senses.

AN INTEGRATED CONCEPTION OF AUTISM

The preceding material is almost overwhelming in its complexity. In order to obtain an overview of the concept of autism a summary table of the major characteristics of "autistic perception" stressed by various writers is shown in Table 1.

TABLE 1
Summary of characteristics of autistic perception stressed by various writers

CHARACTERISTICS	AUTHORS
1. Percepts structured to fit immediate wishes and needs.	Freud, Bleuler, Schilder, Rapaport, Werner, Piaget, Murphy
2. Strongly charged with affect.	Bleuler, Rapaport, Schilder
3. Fusion of subjective and objective.	Bleuler, Werner, Piaget, Murphy
4. Nonawareness that reality is distorted. (Based largely on developmental data with young children.)	Werner, Piaget, Murphy
5. Person may or may not be aware when reality is distorted. (Based largely on clinical observations of adults.)	Bleuler, Rapaport, Schilder
6. Percept has primitive meanings of pleasure-pain or acceptance-rejection or schemata.	Bleuler, Schilder, Werner, Piaget
7. Inner determinants (memory, affect, wishes, feedback, etc.) carry more weight than outer determinants.	Helson, Murphy, Hochberg

These are descriptive characteristics and do not include developmental aspects (which are included later in our chapter on maturational factors). A brief synthesis of developmental aspects is useful at this point, however. In the early stages of development there is little discrimination between subjective and objective factors. Elementary "meanings" are formed which are based on primitive forms of acceptance and rejection, and on simple schemata. As the child matures, there is a gradual differentiation of subjective factors such as wishes, needs, and images and objective factors such as the demands of stimuli. Sometimes the perception of reality is distorted by strong affect which has been cathected to earlier memories which produces biases in expectancies and attention. With maturation, outer determinants acquire more and more dominance as "causal" factors in perception; but the earlier, autistic percepts always form a basis from which the more realistic percepts derive.

Thus when one considers autism one must also include some consideration of developmental factors. For example, in Table 1 it can be noted that some writers say that the individual is not aware of being autistic, whereas others maintain that the individual is aware of being autistic. The former writers, however, base their arguments upon observations of young children, whereas the latter use largely clinical material from adult patients. Lack of awareness of distorting reality is more characteristic of autism in children than of autism in adults.

However, the chief characteristics of autistic perception are the following. The percept is affect-dominated and motivation-directed. The percept partially reduces tension or partially supplies satisfaction in and of itself. The percept itself is gratifying, and the lack of correspondence with reality is largely ignored or is pushed out of awareness.

This is not to say that autism is dysfunctional. Autistic perception supplies gratification to the infant and child during the period of his development in which he does not possess means to achieve objective goals immediately. Rapaport has this to say about the functional usefulness of autism: "Autistic thinking appears not only when realistic thinking is not yet or no longer

effective (that is, when the ego is strong and rich in synthetic power and can allow unconscious strivings to come to the fore in the form of inspirations)" (40, p. 432).

As is evident in normal adults in creative work, autism permits delay of goal-reaching. A delightful book by Hadamard (19) gives much importance to fantasy in the early stages in the creation of scientific ideas. Indulgence in fantasy and other forms of autistic cognition by noted scientists has been well documented by the personal reflections of Einstein and other creative thinkers. And artists (26) must "regress" and operate at an autistic level in order to produce successfully. It is only when the individual cannot freely switch from an autistic to a realistic orientation that pathology can be said to be present.

Implicit in the concept of autism is learning as well as motivation. Autistic perception probably follows the lines of classical conditioning in which there is a low level of awareness of association. Also, the function of autism as a satisfier of needs implies that autistic percepts acquire secondary reinforcing properties through their association with drive reduction and need satisfaction. It is also implicit that autism diminishes as the individual matures. This extinction comes about through more and more contact with reality, which produces conflict with autistic modes of organization. The two modes of organizing perception are antipodal, by and large, and realistic modes of perceiving compete with autistic modes for dominance. Extinction, or at least suppression, also comes about through a shift in the motivation hierarchy, and as new motives are acquired they occasion new modes of perceiving. Society supplies social motives and positively reinforces more realistic forms of perception while disapproving of pure autism.

SUMMARY

The products of learning often reveal a great deal about the nature of learning. This is particularly true of autistic percepts. A careful analysis of autistic perception can tell us much about the role of motivation in perception, how it enters into the per-

ceptual process and the limitations of its effects. Following this line of argument, an analysis of experimental and clinical conceptions of autism was made.

Some experimental conceptions of autism are based upon laboratory attempts to produce misperceptions, whereas others are based on research on children. Both types of research have stressed the development of nonveridical perception as a result of the fusion or association of affect with percepts. One of the earliest experimental definitions was that of Chein—that "autism is the movement of cognitive processes in the direction of need satisfaction." Although this definition had decided weaknesses, it did promote considerable research, particularly on the effects of rewards and punishments upon figure-ground organization. It also was the forerunner of the "directive state" theories of perception.

In general, these theories say that we perceive what we wish to perceive. This does not mean that perception is teleological; it means, rather, that our needs and wishes provide quasi-structure giving sets which direct our selection of stimuli and the structuring of their stimulations. Needs do not act as necessary and sufficient "causes" of perception; they function as channelizing sets which may influence but not completely determine perception.

Developmental studies, such as those by Werner and Piaget, tell us other things. They inform us that early perceptions are fused with or are inseparable from affect. Affect is part and parcel of the matrix of early experience and it is only through the impact of society's negative reinforcement of autistic perceptions that veridical perception is ever achieved, even in part.

In contrast with experimental orientations, clinical conceptions of autism have stressed the turning away from the real world. They also stress the development of veridical perception by the growing awareness of the drive aspects of one's perceptions and by the acquisition of more sensory information.

One should not conclude that affective tone is the difference between veridical and nonveridical perception. Both types of perception may be infused with affect, and autistic perception may coincide with veridical perception!

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ffects of Practice
nd Reward

If an individual is given a motor task to learn in which he receives neither reinforcements (in the usual sense) nor knowledge of results, little or no learning takes place. Practice alone does not seem to be sufficient for the acquisition of motor habits (47). Perception, however, may be altered by practice (12). We believe that in perceptual learning practice is not a static, repetitive process; instead, it is a dynamic factor which takes on radically new properties from the fundamental features of perception itself. The title of this chapter hints at a consideration of practice and reward as functionally similar in perceptual learning. Whereas rewards and punishments are functionally grouped together as reinforcers in motor learning, the grouping of practice and re-

wards is more reasonable in perceptual learning. This is a daring statement which demands explanation, since it implies that perceptual learning is fundamentally different from motor learning.

WHY IS PRACTICE EFFICACIOUS?

In a motor learning task, it is easy for an experimenter to conceal the results of the motor activity; that is, there are operations that can be used to prevent the results from being fed back to the performer as knowledge of how well he has performed. These operations leave the performer in the dark, so to speak, although his performance does stabilize around some norm. Within broad limits the experimenter can control the reinforcement schedule and can withhold or give reinforcement as he sees fit. We believe, however, that this is impossible in perceptual learning. As noted in Chapter 2, *the achievement of percepts is reinforcing to a perceptual act.* A clear, definite, and well-organized percept is rewarding; to have wrestled with an unstructured environment and to have won is gratifying (28). In a very real sense, a percept gives knowledge of results of a perceptual act to the perceiver. Admittedly, no outsider gives the information; an experimenter has little or no control over the giving or the withholding of this kind of reward. The ordinary controls used for withholding knowledge of results or rewards are useless. So long as the perceiver is conscious of the result of his perceptual activity, he automatically has a gauge of his activity. This gauge may not always be accurate—*i.e.,* veridical—but it is the only gauge the individual has. This is just like the situation in which the fuel gauge of a car usually registers the correct amount of gas remaining in the tank but occasionally sticks—and we run out of fuel, much to our dismay. Perception may not always be accurate; we may misperceive at times or even chronically, but our perceptions are the only gauge we have to rely upon.

An example of the use of our perceptual "gauge" would be useful. For example, there is an ash tray on the desk in front of us. When we are motivated to carry out perceptual search and appropriate acts, perhaps by the need to deposit cigar ashes, our perceptual activity is reinforced by its end-product—a clear, defi-

nite, and organized percept of an ash tray. No one else has to be in our office to give us a piece of cheese, a pat on the back, a word of praise, or an emphatic "uh-huh" as reinforcement for our perceptual act. With practice, a perceptual act reinforces itself to the extent that the final percept is clear and definite.

All of this does not deny the importance of ordinary external rewards and punishments. The usual variety of reinforcers can add further weight to the reinforcing effect of the percepts themselves. However, percepts momentarily stop perceptual acts and by their nature complete the transformation of the perceived world. It is doubtful whether any "outside" reinforcement can be given at precisely the right moment to reinforce a given perceptual act, although we may be able to approximate the correct moment to give the reinforcer. It seems to follow from what we have thus far proposed that outside reinforcement will be more efficacious when the stimulus environment is relatively destructured and impoverished, so that no clear and definite percept is possible; when the environment is relatively structured and definite, the percepts will be more intrinsically reinforcing than external reinforcers will be. Under the latter conditions, the ordinary reinforcers will produce little additional effect.

The idea that perception carries its own reinforcement is prevalent in other perceptual theories. Postman assumed this when he wrote: "We can conceive of the perceptual process as a cycle of hypothesis–information–trial and check of hypothesis –confirmation or non-confirmation" (39, p. 251). The confirmation or nonconfirmation (reinforcement or nonreinforcement) stems from the structuring results of the perceptual act itself and does not stem from external reinforcers. Hebb (20) also implicitly assumes that the final structuring of a percept (the firing of a *t*-assembly of neural cells in his system) is equivalent to reinforcement of the preceding structuring activity. Also, the very lack of stress laid upon external reinforcers by the Gestalters implies that they too feel that there is little or no necessity to consider external reinforcement. Perceptual activity seems to differ vastly from motor behavior; and the scientific conception of reinforcement must be different for the two systems.

Besides its "reinforcement effect," practice of perceptual acts

also alters the structuring of percepts through two indirect mechanisms. First, in practicing a perceptual act the perceiver often develops a judgmental frame of reference against which he subjectively evaluates subsequent perceptual acts. Secondly, each time a percept is structured, new memoric traces are laid down; the more frequently the percept is formed, the more often are laid down these memoric traces, which articulate with subsequent percepts. Practice can alter the perceptual process through either of these two mechanisms.

Of course, a change in the judgmental frame of reference does not necessarily constitute a change in perception. For example, almost any perceptionist who has worked with the Müller-Lyer illusion for a long time can, by *judgment*, adjust the length of the variable line to within a gnat's eyelash of the fixed line, but he will tell you that he now *perceives* the variable line as too long. Practice with the illusion has not changed the individual's perception of it. He still has the illusion. Practice has merely altered the perceiver's judgments. This is not always the case, however. While we are willing to grant the occurrence of such instances in which perception and judgment are clearly not the same, we contend that in many everyday life situations judgment does influence perception and vice versa. Our judgment as to the identity of an unknown object at a distance influences our perception of its size, or, conversely, our perception of the size of an unknown object influences our judgment of how far away it is and of its identity.

Perception can also be influenced by its intimate relationship with memory. This was recognized by Wundt and Titchener, who contended that sensations (raw materials of percepts for their theory) fused with images (derived from memory) and other sensations to bring these bare sensory impressions into a meaningful focus of consciousness. Within Titchener's system, perception of a stimulus derived its "meaningfulness" from its context, part of which was contiguous perceptual stimuli and part of which was the contents of memory. The system of the Gestalt school differs from Titchener's, but, as noted by Koffka (32, 33), perceptual and memoric activities articulate in the

process of structuring percepts. Koffka describes how this occurs:

> What is the action of the organism when it responds to the two-noise stimuli? [Koffka is describing two successive auditory clicks.] Certainly not, as was previously supposed, simply the two sensation-processes. For each sensory response to an external stimulus is a process in the nervous system changing the existing state of the system until it is in equilibrium again with the force impinging upon the sense organ. Therefore, when a second stimulus strikes the sense surface right after the first has stopped, the organism must change its present state, which was in equilibrium until the first stimulus, into a new state, which will be in equilibrium with the second stimulus, and in order to do this must pass continually through all the stages intermediate between the initial and final stages. Thus, the effect of the second stimulus is dependent upon the effect of the first, the *direction* of the process of change is a direct function of the relation between the two levels of equilibrium (31, pp. 50–51).

Neither perception nor memory is a static system; each is dynamic in character, moving in the direction of wholeness and structuredness. What effects take place in one of the two systems govern to a certain extent what effects can take place within the other system. The same conclusion is quite evident within the "hypothesis theory" of Bruner (6) and Postman (39), since the hypotheses must be tried and checked against some referent —which is presumably the contents of memory, although they never explicitly say so.

THE DEVELOPMENT OF PERCEPTUAL FRAMES OF REFERENCE

Repeated experience with a variety of stimuli often establishes some kind of reference framework against which other subsequent and contiguous stimuli are judged. Many of us have friends who wear only somber colored neckties such as faded greens,

blacks, and dark browns. Our repeated experience with these friends establishes an expectancy of "dull" ties. However, let our friend wear a pale yellow tie and it is perceived as *violently* yellow in color. Why? The new tie contrasts strongly with our acquired perceptual frame of reference. In everyday life as well as in the laboratory we constantly establish frames of reference against which subsequent perceptual material will be judged. Repetition of a set of stimuli affects our norms and our entire general orientation. The development of perceptual frames of reference with practice becomes, consequently, an important facet of perceptual learning.

However, as Rogers cogently says: "Few concepts are so widely used, with so few attempts at definition or explanation, as this concept of frame of reference" (43, p. 5). We must approach the concept with caution. An early discussion of it was given by Sherif in describing the results of his work on the autokinetic phenomena. Sherif states:

> When individuals perceive movements which lack any other standard of comparison, they subjectively establish a range of extent and a point (a standard or norm) within that range which is peculiar to the individual. . . . This subjectively established norm serves as a reference point with which each successive experience is compared and judged to be short, long, medium—within the range peculiar to the subject (44, p. 96).

The reader may recall that in Sherif's autokinetic experiments the individual sat in a dark room and looked at a point of light. The light was reported as moving. Some subjects saw the light as moving several feet, while others saw the light as moving only a few inches. With repeated experiences the range and the norm of movement stabilized, a result very similar to that obtained by Thorndike (47), who had his subjects attempt to draw a four-inch line while they were blindfolded. In Thorndike's study the subjects' judgments became less variable with practice and tended to stabilize around some norm characteristic of the individual, although the individual was not necessarily more accurate. As Thorndike concluded:

> All educational doctrines which attach value to experience or activity as such, irrespective of the direction of the experience or activity and of its consequences, are made less acceptable than before. Experience, in the sense of merely confronting and responding to the situations of life, can hardly be a powerful agent for either good or harm when several thousand repetitions of such an experience do so little (47, p. 15).

Thorndike, of course, was using *accuracy* as the criterion of learning; accuracy may not necessarily be achieved in a stable frame of reference and his data do show a stabilizing effect.

Both Sherif's and Thorndike's work indicate that perceptual frames of reference develop with practice and that these frames of reference have two simple features—a limited range and a kind of centroid or norm. However, one should not conclude that such frames of reference develop from nothing into something or that they are constructed piecemeal. At any given moment there are adaptation levels and ranges in the maps of perceptual fields (22, 23).

The earliest perceptual experiences of the child are fieldlike in this sense. An infant is seldom in a laboratory and consequently rarely receives pure tones; instead, he receives a multitude of sounds which *immediately* provide a range and an adaptation level of auditory experience. The infant's earliest visual experiences are structured as figure-ground articulations; visually, an instantaneous range of stimulation is received and adaptation levels within that range immediately assert themselves. As Helson describes vision: "We must regard the visual mechanism as a system capable of extremely rapid change, any momentary state of the system representing a quasi-stationary process in dynamic equilibrium" (23, p. 298). In short, the individual always, or nearly always, has a perceptual frame of reference.

These *tentative* perceptual frames of reference are not fixed and immutable, however. They shift, consolidate, and become more rigidly structured with the accumulation of experiences. As the individual grows or as he progresses through a psychophysical experiment, he encounters stimuli *outside* the range of

his previous experiences; the range of his frame of reference extends itself to include these new experiences. The individual acquires knowledge of the variety of experience of which he is capable; his qualitative reference frames become enriched in the sense of being extended, and perceptual experience converges toward the *full* range of which he is organismically capable. Many independent and partially dependent dimensions of perceptual experience unfold and become articulated into meaningful spheres of experience.

Although he is writing about psychophysical experiments rather than about the broader experiments of life, Helson's (22) comments are pertinent. He writes:

> That judgments are affected by past experience and practice even in simple psychophysical experiments is generally recognized. *O*s bring into the experimental situation ideas of loud, soft, heavy, light, pleasant, unpleasant, from their general experience and are particularly influenced by stimuli to which they have been responding in previous experimental sessions. Judgments of stimuli change with practice although they tend to stabilize rather quickly once frames of reference become established (pp. 23–24).
>
> Fundamental to the theory is the assumption that effects of stimulation form a spatio-temporal configuration in which order prevails. For every excitation-response configuration there is assumed a stimulus which represents the pooled effect of all the stimuli and to which the organism may be said to be attuned or adapted (p. 2). . . . There is an AL * for every moment of stimulation, changing in time and with varying conditions of stimulation. It is a function of *all* the stimuli acting upon the organism at any given moment as well as in the past (p. 3).

The situations about which Helson is specifically theorizing are psychophysical experiments; the perceiver is asked to report on a *range* of stimuli which are typically ordered along a single

* AL is short for Adaptation Level, which refers to the stimuli in a series which evoke a neutral response; it is the subjective centroid of the stimulus series about which perceptual judgments are ordered.

physical continuum. These may be a set of weights varying from 200 to 900 grams, or a set of tones varying from 100 to 1000 cycles per second, or a set of colored lights ranging from 500 to 700 millimicrons in wave length. Practice is not with a single stimulus * but with a series of stimuli.

Although Helson (21, 22, 23, 24) has reported on a number of experiments, it is better for our immediate purposes to present a hypothetical case. Consider a lifted weight experiment. The observer-subject is blindfolded and then instructed to lift the weight in front of him. He is told that he is to say whether the weight is (*a*) very, very heavy, (*b*) very heavy, (*c*) heavy, (*d*) medium heavy, (*e*) medium, (*f*) medium light, (*g*) light, (*h*) very light, or (*i*) very, very light. He is then given each of the weights in the series, *e.g.*, weights varying between 400 and 600 grams, to lift to familiarize himself with the series. This probably establishes a *tentative range of experience;* the subject gets some rough idea of how heavy the heaviest weight is going to be and how light the lightest weight is going to be. Then the experiment proper begins. An absolute judgment is made about each stimulus individually, the stimuli being presented in random order. It is found that the subject judges the 475-gram weight to be "medium," while weights over that point are judged to belong in the heavy categories and weights under that point in the light categories. The 475-gram weight is the subject's adaptation level point, the point of neutrality in the series.

If the study is modified by having the subject lift a *comparison stimulus* before each judgment, the adaptation level point will shift. If a 900-gram weight is used as the comparison stimulus, the *AL* will shift upward and more stimuli will be perceived as in the lighter categories; if a 100-gram weight is used as the

* We have tried to use the term "stimulus" consistently as meaning a source of physical energy which (*a*) can be converted into receptor energy and (*b*) *E* can manipulate directly or indirectly. However, as the Gibsons remark: "Stimulus is a slippery term in psychology. Properly speaking stimulation is always energy at receptors, that is, proximal stimulation. An individual is surrounded by an array of energy and immersed in it. This sea of stimulation consists of variation and invariants, patterns and transformations, some of which we know how to isolate and control and others which we do not" (16, p. 35).

standard, the *AL* will shift downward and more stimuli will be judged in the heavy categories. *The entire frame of reference will shift.* If the 900- or 100-gram weights are included in the original series and not used as a comparison stimulus (an anchoring point), then the *AL*s will shift upward or downward, but not as much, since the members of a series do not anchor the frame of reference as rigidly. There are limits, of course, on the effectiveness of a comparison stimulus—for example, a .5-gram weight will have virtually no effect, possibly since it is near the absolute lower threshold for perceiving weights (41).

If one looks at these hypothetical data more closely, he will find that the judgment of "medium" is not constant throughout the study. As the subject has more and more practice with the series, his judgment of "medium" shifts as he accumulates experience with the weights until the perceptual frame of reference stabilizes. This is what we mean when we say that the perceptual frame of reference develops with practice. However, unless practice is extremely prolonged, stretching out over months instead of hours of practice, the tentatively developed perceptual frame of reference will be transitory, that is, it will be only a momentarily established schema which gives way with the introduction of a new situation; the perceptual schema is not likely to become a highly stabilized memoric schema such as Bartlett (4) has described.

The distinction we are making between perceptual and memoric schemata is very nearly the same distinction that is made today between recent and delayed memory. Hebb (20, pp. 60–74) has proposed a dual trace mechanism for memory. Immediate memory (the effects of recent perceptual activities such as Helson discusses) is thought to be "a memory trace that is wholly a function of neural activity, independent of any structural change" (p. 61), a reverberatory activity which is quite unstable. More permanent memory is thought to be dependent upon some kind of structural change in the nervous system. There is a relationship between the dual mechanisms. As Hebb puts it: "A reverberatory trace might cooperate with structural change, and *carry the memory until the growth change is made*" (p. 62).

At the moment we are considering only the first kind of memory discussed by Hebb, although we shall shortly turn to more permanent forms of schemata. Although the two forms of schemata are related, there are important and fundamental differences between them that are too obvious to ignore. Foremost among these is the strong dependence of perceptual schemata, based on recent and immediate stimulus experiences, upon the field of stimulation. Memoric schemata, on the other hand, being overlearned, are *relatively* independent of immediate stimulation, although there may be clues or cues in the immediate environment which trigger them off. What we wish to analyze for the moment is *how* these tentative perceptual schemata get established and *what effects* they have upon perception. The field effects of immediate stimulation have been carefully documented by Koffka (33), Köhler (35), Helson (23), and Gibson (13). We can add little to what they have said other than to note that these field effects govern to a great extent the nature of central correlates—or, expressed differently, the units of perception from which the perceptual schemata will be constructed. This is the first, and a great, determinant of perceptual schemata.

But once two or more "units" (should we say "reverberatory circuits"?) are activated contiguously, what is their fate? In a modern form of British associationism several writers (5, 20, 37, 38) have proposed that such simple "perceptual units" become associated. For example, Osgood says: "*Whenever central neural correlates of projection level signals are simultaneously active and in fibrous contact, either directly or mediately, an increased dependence of one upon the other results*" (38, p. 79). This principle says in effect that the patternings, regularities, and orderings of events in the stimulating environment of an organism come to be mirrored in the structuring of its central nervous system. This is, of course, very much like Hebb's assumption: "When an axon of cell A is near enough to excite a cell B and *repeatedly* or persistently takes part in firing it, some growth process or metabolic change takes place in one or both cells such that A's efficiency, as one of the cells firing B, is increased" (20, p. 62). As the individual repeatedly searches and scans his envi-

ronment, he repeatedly samples stimulation from several sources. These joint samples of stimulation become associated together, apparently by contiguity.

We are impressed by the return of associationism of the British School to the fold of psychology. The words and the methodology have changed, but one clearly distinguishes the old idea in new clothing. Indeed, not only British Associationism but also the Titchenerian theory, which nearly everyone had discounted as dead and gone, seem to be undergoing a revival. For example, compare Hebb (20) and Osgood (38) with Titchener, who wrote: "If a number of vivid perceptions or ideas, whose situational context is the same, occur together under favorable conditions, then the later appearance in the same situational context of any one will tend to be accompanied, according to the circumstances, by the reappearance (as ideas) of the other" (48, p. 166). There is a striking similarity.

The same idea is found in Birch and Bitterman (5) and in Murphy and Hochberg (37). Birch and Bitterman write: "[There is] a process of sensory integration. When two afferent centers are contiguously activated, a functional relation is established between them such that the subsequent innervation of one will arouse the other. Here we postulate a purely afferent process of modification which may operate not only in the absence of concurrent motor activity but in the absence of need-reduction as well" (5, p. 358). Here we are told quite bluntly that *S-S* learning occurs (*a*) on the basis of repetitive pairing of stimulation, (*b*) without any necessary connection with responses, and (*c*) without reinforcement in the Hullian or drive-reduction sense. Almost identical with this conception is the proposal of Murphy and Hochberg that:

> Repeated stimulation alone, without either known satisfaction or known frustration, also leads directly to analysis and to synthesis, i.e., differentiation and integration. . . . Integration tends to achieve homeostasis or stability and offers maximal resistance to change. . . . "Association by contiguity" results directly from such synthesis. . . . The integration into a stable percept of the various simultaneously

> present differentiated "parts" must change the components so that they now bear membership character in the same organization, and each one, no longer independent, "leads to" the others through their mutual relationships with the whole * (37, pp. 340–341).

Repeated joint stimulation of two or more stimuli establishes an association between them. The "contiguity" does not have to be perfect. There is time-binding contiguity by virtue of the fact that stimulation (or reverberatory activity, if you prefer) from a given stimulus *A* persists after the physical stimulus is gone or we have shifted our attention away from it. Subsequent stimulation from another source *B* can be and is associated or synthesized with *A;* as stimulation accumulates, the pooled effect is the formation of perceptual schemata. Such schemata:

> . . . would constitute at least a large part of the matrix within which perception develops, although we should expect not the ideal operation of such tendencies under stationary stimulus distributions but, rather, continually changing temporally-extended interrelations of partially aroused and incomplete frameworks, shifting stimulus distributions, and the feed-back from the developing percept to both" (37, pp. 341–342).

The perceptual schema prepares the way for subsequent stimulation; it is like a plastic mold into which liquid plastic is being poured and yet, being plastic itself, will bend or change its form slightly to accommodate the new materials. It establishes a "readiness," as Bruner (7) has phrased it, for subsequent percepts. Perceptual schemata must *also* govern subsequent input; the perceptual process must turn back on itself as a kind of self-regulatory mechanism. In all likelihood this is what William James (29) meant when he said that our expectancies often increase

* This statement of belief is not shared by all theorists. It is only one side of the "enrichment versus differentiation" controversy between Postman (40) and the Gibsons. Postman contends that perceptual learning develops by "enrichment" of associations, in the Titchenerian tradition (48, 49), whereas the Gibsons (16) contend that perceptual learning develops by finer "differentiations" of stimuli. We believe that *both* mechanisms operate in perceptual learning.

the probability of our receiving what we expect. We believe that this is done by changes in the attentive acts of the individual. His eyes, his ears, his receptors in general are tuned in on selected frequency signals from the environment; he searches for and finds specific forms of stimulation; and he inhibits (27) at a subcortical level those signals which are "noise" in the sense of not being relevant to the perceptual schemata at hand (7).

PRACTICE, PERCEPTION, AND MEMORY

In the foregoing section, we have asserted that it is impossible to understand the perceptual act fully without taking into consideration the intimate relationship between perception and memory. Memory and perception do not function as completely independent cognitive systems. We remember events that we have perceived, and memories that are active at a moment articulate with perceptual processes which are active at that moment. Memory provides a meaningful context into which percepts may be fitted, and perceptual structuring plays a major role in the construction of the memoric frame-of-reference. As documented by Bartlett (4) and Wallach (53), there is an intimate interplay between perceiving and remembering. Of course, there are useful distinctions which can be made between the two. We should hesitate to call a response perceptual unless an immediate, physical stimulus is present. Perceiving, however, is not restricted solely to the time when the perceptual stimulus is present; the perceptual act continues for a short while after the physical stimulus is removed. This lag can be accounted for largely through the differences in duration of stimulus and of stimulation. Stimulation persists for a short time after the physical stimulus is removed, and perceiving is more accurately termed a function of stimulation than a function of the stimulus. This continuance of stimulation after removal of the stimulus produces a dynamic translation of perceptual processes into memoric traces, a gradation of perceiving into remembering (see Koffka, 33, pp. 591–614).

It then follows that repetition of a perceptual stimulus and perceptual acts may "indirectly" influence perception through a

"direct" effect upon memory. Some theorists, such as Allport (1) and Henle (26), who have examined the role of motivation, value, affect, and practice in perception contend that these factors work upon immediate memory rather than perception. From our own point of view it does not matter whether these factors enter perception by the front door or by the back door so long as there is an effect in perception which is more or less cumulative. We agree with Henle that it is important to know the source of the effect; otherwise we cannot carry out as precise experimentation as we would like. Henle's scholarly analysis of the attendant problems supplies us with many possible hypotheses. Among others she proposes for "explaining" the effects of motivation upon perception, she lists the following:

> A need or attitude may operate as a vector, pointing in one direction rather than another. . . . Closely related to pointing may be the organizing effects of needs and attitudes. . . . The perception of other relations is likewise influenced by needs and attitudes. . . . The need or attitude may supply context. . . . Needs or attitudes may animate, enliven, activate, or give outstanding position to relevant parts of the cognitive field (23, pp. 426–429).

We are impressed by a general feature of her analysis, that the "structuredness" of perceptual stimuli and the changes in "structuredness" in memory influence the strength or probability of percepts.

This may occur because perceptual traces do not articulate with randomly selected samples of memoric traces nor do they articulate with memoric traces which are incoherent and disorganized. Memoric traces have a pattern, a structure, or schema. Perceptual traces do not articulate with memoric traces only; they articulate with memoric schemata. The structuredness of events in memory can certainly determine the meaning and structure of percepts through the articulation process. This is the major point made by Tajfel (46) and McCurdy (36) who contend that the effects of motivation and value upon perception can largely be understood by taking into consideration previously developed memoric schemata. They contend that we

overperceive valued stimulus objects only if we have previously developed memoric schemata in which value was correlated with size. As Tajfel says: "The sharpening of differences resulting in overestimation of valued stimuli would occur only when, in the class of stimuli with the attribute of value, an increase in physical magnitude is correlated with the increase in value" (46, p. 203). When this is the case, our memory commits a "good error" (36).

The interpretations given by Tajfel and McCurdy rest on the concept of schemata which was originated by Sir Henry Head (19) and developed by Bartlett (4). It has proved to be a useful concept. Although the term has many ramifications, schemata are basically structured patterns of experience and action. The "reliable" aspects of experience and action form a sort of skeleton framework around which less "reliable" aspects of experience and action can be organized. By "reliable" we mean those aspects that are repeated over and over again in different contexts. The ecological distribution (8) of stimuli and motives are linked with an economical distribution of action. Certain experience-action patterns repeat themselves; practice merely means that there is repetition, and repetition of experience-action patterns tends to build up memoric schemata. We recall what we did and what we experienced in various settings, and our perceptual expectancies tend to conform to the ecological distribution of events as we recall them.

Our acts of attending and their sequence are probably also governed by schematic sequences of remembered experiences and actions. Schemata begin their work upon perception before the perceptual stimulus occurs, through their effect upon expectancies and acts of attending, and continue their dynamic interplay with the perceptual process until the final percept is structured and assimilated into the memoric frame of reference. Elaborating on the effects of schemata, Vernon says:

> The schemata operating in perception perform two functions: (a) They produce a condition of expectation in which the observer is not merely on the *qui vive*, but also knows what to look for—what particular sensory data to select from

> the incoming flood. (b) He then knows how to deal with these data—how to classify, understand, and name them, and draw from them the inferences that give the meaning to the percepts (52, p. 186).

Supporting evidence for this generalization exists in the work of Djang (11), Gottschaldt (17), Hanawalt (18), Henle (25), and Atkinson and Ammons (3), among others. Gottschaldt's studies (17) are the classical examples. In his experiments subjects were shown a complex figure in isolation and then were requested to find this figure in an even more complex masking figure (the basic form of the Gottschaldt task as we know it today). As his subjects had more and more practice with a given form, they found it more often, in different masking contexts, and more rapidly. In short, the probability of recognition increased and the latency of recognition decreased.

Essentially the same paradigm was followed by Djang (11) and Hanawalt (18), both of whom corroborated Gottschaldt's findings. Hanawalt even retested his subjects after periods of no further practice up to three years and found that recognition latencies had still further decreased, indicating an extreme durability of practice effects.

One might erroneously conclude from all this that mere repetition of stimuli is sufficient for perceptual learning; such is not the case. There is an important difference between motivated practice and unmotivated practice. If a subject passively reproduces a perceptual stimulus over and over again, then he will *not* show perceptual learning (2). There must be intentionality to organize and structure the perceptual stimulus; there must be motivation to analyze, to synthesize, to structure the stimulation.

But once motivated practice occurs, thresholds lower and the practiced percepts are more easily attained. We believe this is the primary reason why visual-duration thresholds for words covary with frequency of occurrence, as shown by Solomon and Howes (45). Learning to discriminate visual and auditory patterns as words is motivated learning by practice; all children are highly motivated to learn to decode and encode the language they see and hear. Although in the early stages of language learn-

ing there is some external reinforcement, supplied largely by parents and teachers, a large part of the learning that takes place is perceptual differentiation by motivated practice. The more frequently a "word" is seen or heard, the more often the individual practices discriminating among the complex stimulus patterns, and in general the more rapidly he can recognize the "word." Those aspects of speech sounds that are irrelevant for the necessary discrimination—*e.g.*, nonphonemic but frequently repeated sounds such as glottal stops in English—do not show lowered thresholds largely because practice of these sounds is nonmotivated practice.

These problems and others on the effects of practice upon perception have been succinctly summarized by Ammons (2). As he points out, the effects are not simple; even the definition of "practice" is not perfectly clear-cut. Sometimes practice refers to the duration of continuous exposure of a stimulus; sometimes it refers to repeated brief exposures of a stimulus; sometimes it refers to the number of times a percept has been achieved, regardless of time. We have tried to use the latter definition of practice consistently, although it does not fit too comfortably with many experimental settings. For example, with a reversible figure such as a Necker Cube (see Chapter 13 for example) it is much more practical to use duration of continuous exposure as an independent variable than it is to use frequency of reversals.

PRACTICE AND REWARDS—A COMPARISON

We have contended that practice and rewards are functionally similar in their effects upon perception. It must be obvious, however, that there are and must be differences between the two variables. A comparison between the two is in order. We begin by noting that "repetition" of stimulation is only repetition in a very molar sense. It is repetition only in the sense that *some* of the energy from the *same* physical stimulus source is received by the sense receptors which translate or transform the stimulus into stimulation. It is doubtful that a stimulus source is received in an identical manner from moment to moment; it is more probable

that a sample of its energy is received from moment to moment. Practice is not merely repetition of the same sample; as a process it ordinarily denotes successive sampling from a relatively invariant stimulus source. It follows that practice is the mechanism by which the organism accrues information about its environment. Practice, then, does three things: (*a*) It is responsible for sampling the environment adequately so that memory can become a more stable, invariant representation of the environment, (*b*) it establishes correlations between stored sensory information by jointly sampling from many stimulus sources simultaneously, and (*c*) it establishes expectancies about the environment in the form of memoric schemata. Once the expectancies are established, further practice reinforces expectancies by the mechanism of selective attending, or selective sampling, which further corrects schemata toward a representation of "what is out there."

Rewards seem to do much the same thing. If we sample from the environment adequately and if we use our stored information in our activities, then the likelihood of our being rewarded is increased. Rewards reinforce the searching or scanning activity, biasing our attentional acts and thus governing what is put into memoric schemata. This effects constant errors in our schemata. The schemata will still be highly correlated with "what is out there," but the whole frame of reference will be shifted in one direction or another. An appropriate example is that described by Tajfel (46) in discussing why we tend to overperceive the size of coins. Our practice with coins has produced, by repeated sampling, a schema of coins which vary along a dimension of size. The more valuable a coin is, the larger it is. (Tajfel omitted the dime from consideration.) As we use coins, we sample their sizes and we buy things. We are rewarded by the coins. Since the amount of reward or satisfaction depends upon our discriminating between sizes of coins, the reward value of coins reinforces discrimination of coin size. Since we make more accurate discrimination of coin sizes, we tend to perceive the differences in their sizes more accurately than we perceive differences in disks. Both practice and reward can function to build up and consolidate size-value schemata.

Schemata built up by practice alone and schemata built up

by practice-reward would not yield identical effects in the long run. There is less active participation by the individual when only practice is used, and there is less motivation to attend selectively in further sampling from the environment. In the case of schemata which incorporate values and motives, the individual begins selectively attending and selectively expecting, and consequently such schemata will exert pressure upon the perceptual process. The world of experience will be assimilated to the individual's values, just as at an earlier stage rewards were assimilated into the world of experience.

This dynamic interplay between reward-cathected schemata and the acts of perceiving can produce "misperceptions"—perceptions which deviate considerably from veridicality, although the individual acts as if they were veridical. For example, in 1951 there was a Cadillac model which was shorter than the Buick Roadmaster. One of us (C.M.S.) asked a number of his friends which of the two was longer, when by happenstance the two models were parked side by side. Invariably the observers would glance at the two cars and say, "the Caddy is longer." They "knew" that Cadillacs were longer than Buicks because they cost more. They looked at or attended to the two cars *only* long enough to identify them; they did not attend to the two objects long enough to take in the cues necessary for effective size discrimination.

This illustrates the principle through which reward-cathected schemata produce "misperceptions"; individuals misperceive by selective omission of the attentive acts necessary for veridical perception. However, we do not believe that this principle is sufficient. It must also be obvious that under certain conditions we attend to reward-cathected stimuli quite intently; *e.g.*, a beautiful symphony such as César Franck's *Symphony in D-Minor* can so capture our attention that even minor flaws in the performance will be perceived immediately. If our percepts must correspond closely with our reward schemata to gain gratification, then we are likely to attend more attentively than normal, and consequently we discriminate more finely.*

* We also discriminate more finely events associated with punishment or which are noxious under certain conditions presented in Chapter 6.

There is still another principle that we must discuss. Let us begin with an example. A very young child pays little attention to money; with development the child comes to associate reward values with money and pays more attention to it, often looking at the engraved figures, dates, mottos, etc.; but with full growth the adult uses money without looking at it. This suggests that as rewards and reward symbols *become assimilated* into an individual's schemata, he directs his attention toward them. However, once the rewards *are assimilated* into schemata, the individual stops paying very much attention to them unless, as already noted, attention is still necessary for gratification. Tolman (50) presents essentially the same idea when he notes that VTE, vicarious trial and error, or "looking back and forth" at a choice point, *increases* as training in a reward situation progresses, and then *decreases*.

SUMMARY

In perceptual learning, practice is a dynamic factor, whereas in motor learning it is a static factor. This is because (*a*) the achievement of percepts is reinforcing to a perceptual act and (*b*) perceptual activity itself is gratifying. Practice affects perception by establishing tentative judgmental frames of reference and by establishing stable memoric schemata which articulate with perceptual data in the process of achieving conscious percepts. Rewards produce similar effects by motivating the individual to finer discrimination and by reinforcing perceptual acts. Rewards also become cathected to schemata and consequently alter the individual's expectancy system as well as his acts of attending.

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6

Effects of Punishment on Perception

An individual's world is centered in those events which are satisfying and those which are punishing. Man seems to reach out, search for, and seek to incorporate, either physically or symbolically, those things which are rewarding to him. He seems to orient his ways of responding, his modes of perceiving, and his energy resources toward seeking pleasure. But the conditions of life are such that no one can carry out such pleasure-oriented actions without running into obstacles and without being punished for his actions. One has to learn to modify his actions and his goals so that he can give up immediate pleasure and can endure a certain amount of discomfort in order to reach long-range goals. This is essentially what Freud (5) proposed when

he defined primary and secondary process activities and pointed out that conflict was necessary for growth. Or, as Sakini summarized the issue in *Teahouse of the August Moon:* "Pain makes one think. To think makes one wise. And wisdom makes life more endurable." This encountering of punishment and pain in the act of goal-seeking is assuredly a major factor in perceptual learning. We need to explore the consequences of the association of punishment with percepts, and to trace the residual effects of such associations in several aspects of perceptual organization.

Although the influence of punishment-associations on perception is marked and vivid and although nearly every clinical case bears the hallmark of such effects, there is a paucity of experimental information about the process by which their influence develops and operates. A definitive program of thinking and research in this area would contribute quite significantly to our understanding of perceptual learning. But first we must develop from experimental evidence some kind of over-all conception of the conditions and variables entering into such perceptual learning involving the factor of punishment.

The experiments in this area (*e.g.*, 1, 4, 10, 15, 24) have not yielded consistent results. However, the use of different experimental procedures and tests, of different stimulus materials, of different intensities of punishment, etc., make direct interexperimental comparisons almost impossible. A careful scrutiny of such studies is essential for teasing out significant variables in this kind of perceptual learning.

There have been many allusions to an individual's emphasis upon the punished or threatening aspects of a perceptual field. Tolman (25) speaks of punished events standing out as things to be avoided. Yet there are studies which indicate that under certain conditions punished events are "perceptually repressed" and are underemphasized in the perceptual field (*e.g.*, 4, 10, 15). The questions facing us, in general, are these: What are the conditions of learning which lead to *perceptual emphasis* and what are the conditions of learning which lead to *perceptual de-emphasis* of punished materials? It is *only* by systematically studying the conditions and parameters of perceptual learning that we can understand the why and the how of perceptual functioning.

The reader may object to our *not* using the terms *perceptual vigilance* and *perceptual defense.* We object to the use of the term perceptual defense, primarily because the word "defense" is double-barreled in meaning. What is really referred to in such cases is a de-emphasizing of, or desensitization to, certain aspects of the perceptual field. Clinically, *both* emphasis and de-emphasis are "defenses"—hyperacuity can be as "defensive" as is hypoacuity. We think that many researchers have been deceived by the semantic connotations of "perceptual defense." There is virtue in abandoning the term. The primary need is to specify the conditions under which punishment will tend to accentuate and strengthen a perceptual response associated with it, and the conditions under which association with punishment will tend to disrupt or weaken a perceptual response.

There are both theoretical and operational difficulties in this area. The theoretical problems are manifold, but the one that causes the most trouble is how to separate the two functions of a noxious stimulus. A noxious stimulus is a reinforcement stimulus (both positive and negative) and a motivating event (both positive and negative). The specific effects of a noxious event are theoretically determined by a number of experimental variables, among which various studies have emphasized the *CS-US* time interval, possibilities of escape or avoidance, intensity of the *UCS*, and delay of subsequent tests of effects. The picture is an intricate one since the effects of one variable can counteract the effects of another; experimental operations are poorly coordinated with theoretical constructs and vice versa. Consequently, we are compelled to give detailed accounts of experiments in this area.

ELECTRIC SHOCK AS PUNISHMENT

Electric shock has been used as a noxious stimulus in more perceptual learning studies than any other kind of punishing agent (1, 3, 4, 10, 15, 18, 24). There are many practical reasons for using electric shock. First, it is commonly agreed that shock is noxious; secondly, electric shock is easy to administer and to control; and thirdly, time intervals, intensity levels, and so on

can be more uniformly repeated. To be sure, there are also drawbacks. Subjects avoid such experiments; "anxiety" often skyrockets when the subject sees the shock apparatus; and there are wide individual differences both in tolerance and adaptation to shock and in means of dealing with shock.

In the studies to be reviewed here we have tried to present concisely the following information, when available in reports: (*a*) physical aspects of the electric shock used, such as intensity, units in which intensities are reported, method of inducing shock, and the place where shock is presented on the body; (*b*) time intervals between perceptual stimulus and shock; (*c*) experimental setting (whether pleasant or dingy, apparatus exposed or not exposed, pleasantness or unpleasantness of surroundings, etc.; (*d*) subject variables—age and sex of subjects, subjective evaluation of shock, and whether volunteers or nonvolunteers were used; (*e*) the possibilities of escape, avoidance, or no escape–no avoidance; and (*f*) the perceptual aspect studied and in what way it was modified.

We begin with a recent study. Ayllon and Sommer (1) had women undergraduate students at Kansas University associate electric shock—approximately 50 v—with certain aspects of an ambiguous tactual field consisting of reversible faces. The punishing stimulus was administered three seconds after the perception of one of the two faces in the training trials and was not administered after the perception of the other face. It was administered in such a way that the subject could partially escape by raising her fingers from the electrode. In the ambiguous test situation the subjects (after the test trials) who rated the shock as moderate or very unpleasant reported more shocked than nonshocked faces in the ambiguous situation. The subjects who rated the shock as not unpleasant or mildly unpleasant perceived more nonshocked than shocked faces in the test situation.

These data seem contradictory to those obtained by Smith and Hochberg (24) with Cornell University undergraduates. Their subjects were shown "improved" drawings which consisted of solid black or white faces on contrasting backgrounds. The drawings were "improved" so that only one face could be seen at a time. One of these profiles was associated with an electric

shock (voltage not stated) while the other profile had no punishment stimuli associated with it. In the test series both faces could be perceived equally well, as determined by prior testing with control subjects, but subjects perceived the nonshocked face more frequently.

Dulany (4) also studied the effects of electric shock association on "clarity of perception." He ran 32 subjects, 16 male and 16 female undergraduates at the University of Michigan. Four stimulus figures were presented at a time; a circle, a diamond, a square, and a triangle. Their spatial arrangement in the four quadrants was counterbalanced in a Latin square type design. Each card was shown for .12 of a second tachistoscopically. If they chose the randomly assigned figure as "clearest," an electric shock of two seconds' duration was given to their leg calf two seconds later. (The intensity of the shock was individually determined by seeing how much shock each subject could be persuaded to take and then increasing the intensity slightly.) Sixty-four training trials were followed by an assessment phase. Dulany reports that his subjects perceived the nonshocked figures as "clearest" following the training. Two paradigms of training were used which were essentially the same: in one, his subjects associated one of four figures with shock and in the other they associated three of the four figures with shock.

Pustell (15) also used the same materials and paradigm except that he presented the "unbearable" (determined by self-judgment by subjects) shock .2 of a second after the percept was given. His results showed no uniform effect but a striking sex difference; all of his 12 male subjects perceived the shock-associated figure as "clearest" in the test period, whereas 9 of his 12 female subjects perceived the nonshocked figures as "clearest." His male subjects reported that they kept trying to figure out some way to *escape* from shock, whereas most of his female subjects reported that they more or less passively submitted. The crucial factor in Pustell's study (15) is that *the males tried to escape whereas the females did not.*

It seems that if a percept just precedes a punishment stimulus, *e.g.*, a painful electric shock, then that percept comes to be a warning sign that pain will follow. If the individual can avoid

the punishment by recognizing the percept as a sign of subsequent pain, he will operate wisely (in the biological sense) by becoming alert to the occurrence of that percept. As a consequence of such perceptual learning the punishment-associated percept will stand out, be dominant in, the individual's perceptual field. However, if there are no means by which the individual can physically (overtly) avoid the punishing agent, he will have to fall back upon his next line of resources; he will turn toward a primary-process mechanism of denial that the signaling perception has occurred. In effect, he will "repress" the punishment-associated perception. We may restate these arguments as follows: If a perceived stimulus closely precedes a punishing stimulus event and some form or degree of escape from the punishing event is possible, then that perceived stimulus will be dominant over a nonpunished ("neutral") competing stimulus event in the perceptual field; but if no escape is possible, then the punishment-associated stimulus will become less dominant in the perceptual field.

This interpretation of Pustell's results in terms of escape possibilities seems to be supported by Reece's study (18). Using a two-by-two analysis of variance design—escape versus no escape and predictability of shock versus nonpredictability—as well as a control group with no electric shock, Reece found that the threshold for nonsense syllables associated with shock under escape conditions was lowered, whereas the threshold for syllables associated with shock under no escape conditions was raised. It is difficult to tell whether these results reflect true perceptual changes or whether they merely reflect overt response changes. Reece used an anticipation prompting, paired-associate method of training. In the "escape" condition, if the subject gave the correct associate, the shock was immediately turned off; otherwise, the shock persisted for the two seconds' duration of the exposure of the associated pair. In the "no escape" condition, no response given by the subject turned off the shock for the duration of exposure. In the predictability conditions, shock was always associated with specific pairs of nonsense syllables. In the nonpredictability conditions, shock was randomly administered with various pairs of nonsense syllables. Reece points out that the

reduction of shock probably served as a reinforcement, whereas continuation of the shock during the presentation of the pair of syllables probably served as an inhibitor. His data do seem to support the hypothesis that if a percept is consistently a sign of punishment which can be escaped from by some form of action, then that percept will be dominant in the perceptual field; on the other hand, if a percept precedes punishment which cannot be escaped from, some form of "perceptual repression" takes place.

The position of Bruner and Postman (3) agrees with that of Reece, in that they too consider tension release to be a positive reinforcer. In their study they had adult subjects estimate the size of a metal disk by adjusting a spot of light on a milk-glass screen until it appeared the same in size as the disk. Following this base-line phase, they had one group of subjects pass the disk in and out of a metal grid which was electrically charged. The other half of the subjects did nothing in this phase. Following this training phase, size estimations of the disk were taken again. The control subjects showed no change from their original estimations, but the experimental subjects now overestimated the size of the disk.

The task of passing the metal disk in and out of the charged grid was so difficult that the subjects could not avoid being shocked; however, they could escape by moving the disk rapidly in and out of the grid and the escape could quickly reduce the tension or pain caused by the shock. The overestimation by the experimental group need not necessarily be attributed to the shock at all, however. It is a possibility that this group had more experience with the disk—and the control group would have been a better control group if they had passed the disk in and out of the grid with the grid uncharged.

McNamara, Solley, and Long (10) have also tackled the problems of escape and no escape using the tactual plaques that Allyon and Sommer (1) employed. (See Figure 5.) The subject's task was to trace the profile line, which was indented, with his right index finger.

Subjects could either escape or not escape from an electric shock presented through an electrode to the left hand. Shocks

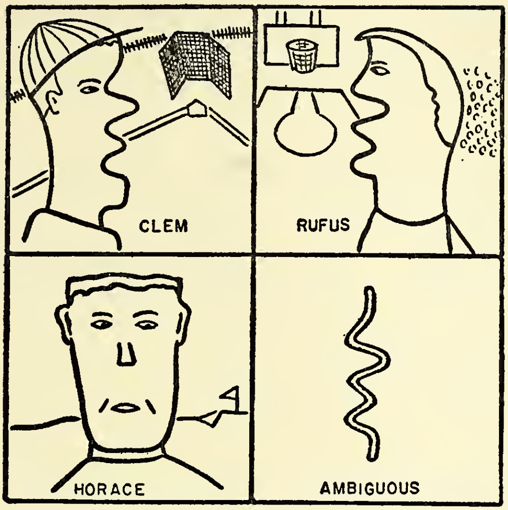

FIGURE 5. *Diagrammatic drawings of training figures (Clem and Rufus), of set-breaking figure (Horace), and of ambiguous test figure used by Ayllon and Sommer (1) and McNamara, Solley, and Long (10).*

of 18, 25, 40, 50, 60, and 75 volts were given for one second duration. After a training period in which electric shocks of a given voltage were administered contiguous with tracing one of the plaques—either Clem or Rufus—with a finger, the subject was blindfolded and was presented with the ambiguous plaque (which had a single contour line) which was to be traced. They found that with increasing voltages there was more and more reporting of the nonshocked profile, this effect occurring more readily under the no escape condition.

These investigators also presented some data which point to some difficulties in using *subjective evaluations* of shock as an *independent* variable as Pustell (15), Dulany (4), Reece (18), Ayllon and Sommer (1), and others have done. In pursuing this problem McNamara, Solley, and Long (10) had their subjects rate the unpleasantness of the shock they were given—no subject knowing what voltage was presented. They found a strong posi-

tive correlation between ratings of shock and physical values in the *escape* condition, but a negligible, positive correlation in the no escape group. These data are shown in Table 2.

TABLE 2

Frequency distributions of judgments of shock's unpleasantness (10) taken after training and testing

VOLTAGES	ESCAPE CONDITION	NOT UP	SLIGHTLY UP	MODERATELY UP	VERY UP
18	Escape	6	2	0	0
25	Escape	2	8	2	1
50	Escape	0	7	6	2
75	Escape	0	0	4	2
18	No escape	0	5	1	0
25	No escape	1	9	5	0
40	No escape	0	9	5	0
50	No escape	1	5	6	2
60	No escape	0	5	9	0

Being able to escape from shock seems to lead to a realistic evaluation of aversive stimuli, whereas no escape does not. No escape conditions produce large individual differences in reaction to noxious stimuli.

All of these studies show us, clearly, that painful associations do influence changes in reported perception and reports of perceptual changes help us better control pain's occurrence. Indeed, the biological utility of various perceptual structurings, in relation to man's need-structures, probably delimits bounds within which perceptual learning takes place. If the conditions of learning are such that the individual can learn redundancies between occurrences of perceptual cues and subsequent noxious or unpleasant stimulation, then those perceptual cues come to stand out in the perceptual field. The higher the conditional probability that painful or noxious stimulation will occur, after a certain perceptual response has occurred, the more likely will a person be to look out for, or alert himself to, such perceptual cues. However, such perceptual structures can only function in this way *if* there are possibilities of avoiding the noxious stimula-

tion by overt action. If the time interval between percept and punishment is too short (15) or there are too many perceptual structures among which to discriminate (4), the individual can only partially avoid the unpleasant experiences. The percept occurs; overt action either fails (through errors) or cannot occur (through too short a time interval); and the individual escapes. In both pure avoidance and partial avoidance or escape conditions, a percept systematically associated with noxious stimulation has the function of "alerting" the organism to danger.

The immediate consequences would be the lowering of thresholds for such percepts. The *long-range* effects would be quite different, *i.e.*, the long-term effects *after* the noxious agent is removed. Perceptual learning would continue and probably grow stronger with repeated testing even though the punishing agent was removed. The individual would have no way of "knowing" that the noxious agent was removed, and hence would not extinguish. Individuals trained under partial avoidance or escape conditions would also be difficult to extinguish, although less so.

Individuals trained under no avoidance, no escape conditions have a second line of defense to fall back upon. We call this "perceptual repression." That is, the associated percept is denied admission to conscious awareness, and our results indicate there is even denial of the unpleasantness of the punishing agent. Reece (18) called this "inhibition," but the name is not important. The important concept is that the percept is inhibited, interfered with, or repressed. These are the *immediate* effects. It must require a great deal of the individual's energy to maintain such active repression. After the punishing agent is removed, less and less energy will be expended.

Rapaport (16) and Sharpe (20) have brought this point home vividly. The effects of associating aversive or extremely unpleasant stimuli with perceived stimuli may not show up immediately. Bindra and Cameron (2) have shown that anxiety tends to incubate and express itself most fully *only* after a delay. How often has one of us had a traumatic experience, such as when a tornado or war or hurricane or flood strikes, and dealt with the problem at hand only to experience tremendous anxiety and fear some time *afterward*! In nearly all the studies which we have

reviewed, a test of perceptual changes was made *immediately* afterward, and we know very little experimentally about the delayed impact of painful associations. Sharpe (20) and McNamara, Solley, and Long (10) are a few who have studied delayed effects. Both studies yielded essentially the same result. Both repression of perceptual events and anxiety become more evident after the delay.

Any clinician can point to multitudinous examples of patients whose anxiety leads them to distort perceptually what they see or hear or feel. And frequently these effects do *not* occur until the individual is an adult and some precipitating event fully arouses or expands past anxieties associated with perceptual events.

OTHER FORMS OF PUNISHMENT

If one were to make a list of noxious stimuli, he would probably include the sound of chalk screeching on a blackboard. How many of us have had the small hair stand out on our necks when we have heard the screech of chalk on blackboard or of fingernails on glass or of metal against metal? Hochberg and Brooks (7) made interesting use of such annoying stimuli. They presented selected tape-recorded bursts of chalk-on-blackboard by means of earphones. Twenty Cornell University undergraduate and graduate students served as subjects. Each was shown four of Gottschaldt's embedded figures, each figure being exposed ten seconds. Two of the figures were continuously presented with the screech recordings and two had no sound associated with them for half the subjects, with the reverse conditions for the other subjects. Thresholds were measured before and after training by means of changing the relative illumination of figures and embedded context with a light wedge until the figure was correctly identified and located. The data for both pairs of figures were pooled in the final analysis. Seventeen of the twenty subjects displayed higher recognition thresholds for the punished figures than for the nonpunished. It should be carefully noted that the training conditions involved contiguous pairing of perceptual stimuli and noxious stimuli, and no escape or avoidance was possible from the annoying stimuli.

A more complicated design was used by Hochberg, Haber, and Ryan, who hypothesized that a "weak and labile memory trace, newly laid down by the brief tachistoscopic exposure, might be eradicated by the violence of almost-simultaneous response . . . the startle response (which may be aroused by fractional recognition of the stimulus) 'automatically' interferes with recognition and recall of briefly presented material" (8, p. 15). These researchers had subjects associate a buzzer with an inductorium-induced shock (amperage or voltage unspecified). The shock followed .5 of a second after the buzzer for 35 trials. The buzzer (*US*) was then, in turn, associated with seven of 14 nonsense syllables (*CS*) for which tachistoscopic recognition thresholds had been individually determined. With one group of eight subjects the buzzer was sounded *simultaneously* with the presentation of the nonsense syllables; for another group of eight subjects the buzzer sounded 0.1 of a second *after* presentation of the nonsense syllables (before subjects could report). A third group of eight subjects served as controls who had no buzzer-shock training but did hear the buzzer sounded with the second threshold measurements. Both experimental groups showed higher recognition thresholds for the buzzer-associated syllables—an effect interpreted as due to interference with the recognition threshold by the strong autonomic reaction to the buzzer. This particular study is especially instructive in that it is the only study, of which we are cognizant, where second order conditioning effects were studied. The interference effect could not be due to "defensive" reactions to the nonsense syllables since they were never directly associated with the noxious reinforcement stimuli. Some internal component, presumably autonomic in nature, aroused by the buzzer-shock conditioning must have disrupted the momentary perceptual trace.

Physical stimuli are not the only form of punishment. As a child matures, social motives and social reinforcers, positive and negative, develop in importance. A spanking from father has quite a different meaning at age five and at age fifteen. At the younger age it is the physical pain that hurts but at age fifteen it is the pain to one's ego that hurts. If a child perceives a situation as one in which he is being evaluated, social approval or

disapproval from an adult may be the overriding factor. Social approval or disapproval probably increases in effectiveness as a reinforcement stimulus or as a punishing agent as one grows older. Individual differences among children, in this respect, are marked. If the child has a personality such that he needs and seeks social interaction, then mere interaction with the experimenter, even though it is of a potentially punishing nature, is valued, and one finds that the act of punishment is operating as an act of reward.

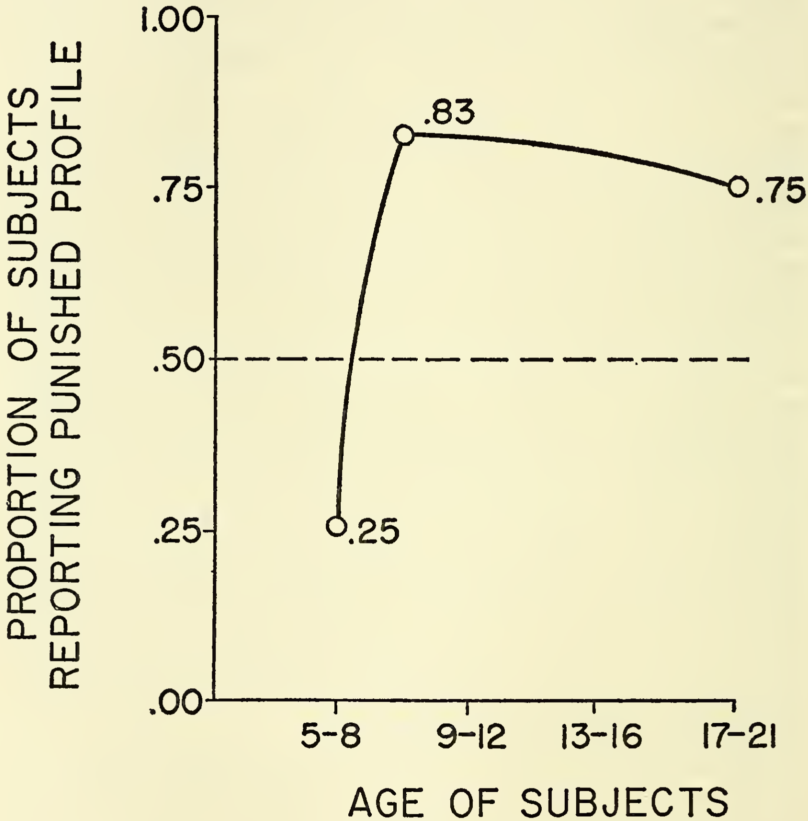

Figure 6. *Proportion of children perceiving the punished profile as figure and the neutral figure as ground.* (Data drawn from Messick, Solley, and Jackson (11) and Solley and Engel (21) to form composite.)

These effects have been particularly noticed with children (19, 21). For example, a little boy may be losing his nickels to the experimenter when a certain perception occurs but will look at the experimenter, smile, and gleefully push his nickels over to the experimenter. It seems that at some ages interacting, even in the context of punishment, is better than having no interaction. Doing something acts to release tension whereas doing nothing serves to maintain tension.

These studies with children just reported (19, 21) point to certain developmental or age factors. Figure 6 shows the results of these studies where monetary loss was used as the punishing event. This figure shows that as age increases children move from primarily repressing the percept (the punished percept being "ground"), to more and more vigilance toward the punished percept. As a guess, it could be said that children between five and eight years of age have not learned efficient modes of escaping from the punishment. As a consequence, they use the more primary mode of repression or denial of the percept. As they grow older and learn to handle the situation, such mechanisms as enjoying the sheer interaction with the experimenter and thus reducing their inner anxiety or as diverting their attention to questions about the apparatus appear; the mild punishment of loss of nickels serves to accentuate associated percepts.

THEORETICAL CONSIDERATIONS

The literature review has made obvious the lack of interexperiment comparability. In nearly every study some operational variables were held constant and some one or two others were varied. It is difficult to separate the effects of the independent variables from their interaction with the fixed values or levels of the constant variables. For example, the time intervals between the perceptual stimulus and the punishing event was varied from study to study: Smith and Hochberg used contiguous pairing, Pustell used .2 of a second, Dulany used 2 seconds, and Ayllon and Sommer used 3 seconds. If only the time interval had been varied, some conclusions might be drawn, but these time intervals represent *fixed* values within each of these respective experiments

and quite different independent variables were manipulated.

In order to compare experiments we are forced to develop a limited theoretical frame of reference. With a great deal of humbleness we present here a frame of reference which we have found useful. Let it be clearly understood that what follows is a model for human perceptual learning under the impact of noxious stimulation.

Time Intervals

There are three types of time intervals of fundamental importance in a perceptual learning experiment involving punishment. These are (*a*) the duration of the *CS* and the *UCS* respectively, (*b*) the time interval between the conditioned and the noxious stimulus, and (*c*) the time interval between trials. Each of these time intervals or durations affects the perceptual system in different ways, and must be considered separately, although their total effects often depend on curious interactions.

Duration of CS *and* US. In most perceptual learning experiments the investigators are interested in how the subject perceives the *CS; i.e.,* the experimenter considers the *CS* rather than the *US* as a perceptual stimulus, although the latter is most certainly a perceptual stimulus too. We must assume, for the present discussion, that both the *CS* and *US* are of moderate intensities, although we shall consider other possibilities later. As the *CS* shortens in duration, it gradually reaches threshold and then goes below the threshold. If the duration is too brief, the *CS* will elicit only a fragmentary perceptual response; as the duration increases, more and more structuring follows the presentation of the *CS* until one reaches a point where the *CS* elicits a fully orchestrated percept.

The same is true of the *UCS* except that the *US* is chosen on the basis of its properties of eliciting strong affect arousal. It should be recalled here that we are discussing noxious *UCS*s. If the *US* is too brief, very little unpleasant affect will be aroused and a weak overt response will be observed. As the *US* increases in duration, more intense affect is aroused and more and more emergency feedback units will be called upon to combat the un-

pleasant affect. If the *UCS* persists, the organism will eventually "adapt" to the *UCS* either by alterations in the sensitivity of the pain receptors or centers or by establishment of a permanent pattern of emergency feedback mechanisms (see Chapter 12) to block the unpleasant affect, as in traumatic avoidance learning (22).

CS-UCS *Intervals.* Again, we must make a restriction. We shall assume here that the intensities of the *CS* and the *UCS* are moderate *and* that the duration of the *CS* is long enough for a fully developed percept to arise and the duration of the *UCS* is long enough to arouse the full potential of unpleasant affect but not so long as to produce adaptation. Trials are assumed to be widely spaced also.

We know from classical conditioning studies (*e.g.*, 9, 17) that between .2 of a second and .455 of a second is needed to obtain conditioning with noxious stimuli. This time interval is usually interpreted as *CR* latency time. However, we believe that this is the time required for the full arousal of a percept by the *CS*. There are studies on "attention" (26) which indicate that it takes a minimum of .2 of a second to direct one's attention to a stimulus fully. And Woodworth (26) points out that .2 of a second is the time it takes a very fast reader to shift his focus of attention while reading. In addition, informal work by ourselves and by Hochberg at Cornell University strongly suggests that it takes approximately .2 of a second for a figure–ground organization to stabilize fully. Like Miller (12), we are literally plagued by a magic number, in this case .2 of a second. Time is of definite importance, although *intensity* and *structure* must also be important.

Let us further develop our case. If it does take about .2 of a second for a simple percept to reach full structure, then a noxious *UCS* presented between 0 and .2 of a second after the stimulation is given to arouse the latter will disrupt the perceptual process *before* the latter can stabilize. The general form of this hypothesis has also been advanced by Smith and Hochberg (24) and by Hochberg, Haber, and Ryan (8). The latter write: "a stimulus which has been conditioned to trauma (electric shock)

becomes capable of producing an internal response which interferes with the tachistoscopic recognition" (8, p. 17). In short, a noxious *UCS can interfere with* the perceiving process. This interference does not take place immediately upon presentation of a *UCS*. Just as the structuring of the perceptual stimulation takes time, so does it take time for the effects of a *UCS* to take place. The *UR* has a latency; if the percept is structured *before* the *UR* is fully evoked, then the *UR* cannot interfere with the perceptual act. It is when the *UR* is being evoked at the same instant that the perceptual act is occurring that there is response competition.

Inter-trial intervals. If inter-trial intervals are not well spaced but are extremely short, then the affective response aroused by the *UCS* will carry over and interfere with the *succeeding* *CS* on the next trial, a conclusion that derives from the work of Hochberg, Haber, and Ryan. As the duration of the *UCS* or the intensity of the *UCS* increases, longer inter-trial intervals are needed to prevent this "backward" interference in perceptual organization.

Characteristics of CS *and* UCS

The intensities of *CS*s and *UCS*s are largely interchangeable with duration in effect (17). As duration lengthens, weaker stimuli can be used; and as duration shortens, stronger stimuli can maintain a constant effect. The reader will recognize this as related to the Bunsen-Roscoe law.

Although intensity *qua* physical intensity is important, other characteristics of the *CS* are more important from a perceptual point of view. A *CS* is never given alone, but always occurs in some context of stimuli. A list of other factors as important as intensity would include: the "embeddedness" of the *CS* in the background stimuli which alters the speed with which a percept arises; the "semantic" meaning of the *CS* when words are used; the attensity (17) (degree to which the *CS* is attention-getting) of the *CS;* the "simplicity" or "complexity" of the *CS*; and the "familiarity" of the *CS*. Summarizing all these variables, an experimenter must study the "speed" with which a given *CS* serves as a perceptual stimulus for a given class of percepts; embedded-

ness, attensity, meaning, simplicity or complexity, and familiarity function alike in governing the ease or difficulty with which a given *CS* can eventuate in a specific perceptual state.

Behavioral Restrictions

It may seem odd to include a section on behavioral restrictions while considering perceptual learning. However, these variables are crucial when considering the association of perceptual stimuli with noxious stimuli. The chief behavioral restrictions are these: (*a*) the individual can avoid the noxious stimuli; (*b*) the individual cannot avoid but can escape once the noxious stimuli occur; (*c*) the individual can neither avoid nor escape.

Biologically, man is equipped to function somewhat differently when restricted in his reactions to noxious stimuli. If he can avoid such unpleasant events, he will learn to do so. This learning involves, principally, active discrimination of perceptual cues which will permit the individual to recognize that punishing events are coming, thus giving him time to avoid them. Avoidance training paradigms, consequently, produce an accentuation or emphasis upon those perceptual cues or patterns which allow the individual to make good his avoidance. Escape training, on the other hand, sensitizes the organism to make fast motor movements, and disrupts the discrimination process (as pointed out in the discussion of temporal intervals). The speed of escape probably increases with the intensity of the punishing event, so that the organism can realistically evaluate the painfulness of the *UCS*. In no escape, no avoidance training, however, the organism must rely upon another line of defense; namely, he must repress the unpleasant affect, make internal adjustments of emergency mechanisms to produce faster adaptation to the *UCS*, and divert his attention from the outer world. These in turn produce a less realistic evaluation of the situation, a greater "autistic" effect, and a withdrawal of cathexes from external events.

Perceptual Repression

An elaboration of these effects of the no escape, no avoidance paradigm might be useful. It is not a sufficient analysis of the problem merely to say that subjects repress the unpleasantness of

the stimulus. "Repression" is a useful descriptive term, but, even clinically, repression is analyzed into more dynamic components. We shall attempt this here. One mechanism by which this repression can be effected is to reinterpret this *meaning* of the punishing event. Reece's study (18) demonstrates this. He asked his subjects why they were shocked. Those subjects run under an escape-avoidance procedure said they were shocked as *punishment,* whereas the subjects run under a no escape procedure said that the experimenter was trying to *interfere* with them or *disrupt* them. The former group focused the meaning of the electric shock on themselves, a self-oriented component of meaning. And the latter group focused the meaning of the electric shock on an outside event, namely the act of the experimenter. In effect, this group could justify the unpleasantness or pain by blaming someone else. Repression could be effected in no escape conditions by placing the blame on another person. This is only one of several possible mechanisms.

Another mechanism which might lead to repression could be the *bracing* effect we all experience when we know we are going to be hurt unavoidably (13). Just as we brace ourselves for an automobile collision to keep from being jolted too hard, we do so in psychological experiments using noxious stimuli in unescapable conditions. We tense our muscles, trying to prevent the arpeggio of pain associated with shock. We raise our physiological defenses, both muscularly and autonomically. Our blood sugar level rises, adrenalin increases, and our entire system adapts itself so that it performs with greater efficiency. We know little about these defensive feedback mechanisms but such are probably the mainsprings of the repression of the unpleasantness.

Still another useful mechanism might be the diverting of attention. By actively thinking about something entirely different we can partially avoid the pain. Hernández-Péon, Scherrer, and Jouvet (6) have shown us that animals block the input of a competing stimulus, at a subcortical level, by attending to another stimulus. Some of the children observed by Solley and Engel (21), in their punishment-neutral condition, began asking questions about the experimenter—who he was, what he did, or where did he live—or about the equipment—how it worked, etc.—and managed almost completely to avoid facing their loss of nickels

as a punishment stimulus. By diverting their attention, or "leaving the field" so to speak, the children effectively repressed the unpleasantness of the punishment stimulus.

These analyses, of course, do not exhaust the possibilities for conceptualizing the dynamics of repression. But they do serve to illustrate some of the possibilities.

SUMMARY

The encountering of punishment and pain in the act of goal seeking is assuredly a major factor in perceptual learning. However, the effects of punishment upon perception are extremely complex; by slightly changing the conditions of association of percepts with noxious stimulation one can reverse experimental effects. There is no universal, single effect.

Most of the work on the theoretical problems of punishment has been on figure-ground organization although studies have been done on recognition thresholds as well as on perceived size. Very few studies have been done to isolate theoretical variables; most studies have used "fixed" variables and one has to look across studies to abstract a theoretical frame of reference.

Variables which affect the outcome of punishment–perception association are (*a*) time factors such as the interval between percept and noxious stimulation, the duration of percept, and the duration of noxious stimuli; (*b*) intensity factors such as the intensity of the perceptual and the noxious stimuli; (*c*) response possibilities of avoidance, escape, or of no escape or avoidance; and (*d*) individual differences in "defense" or "affect-control" mechanisms. Slight changes in the combination of these variables produce considerable differences in effects. Some combinations produce positive reinforcement of perceptual acts whereas other combinations weaken perceptual acts.

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7

As the Child Grows Older

It is often difficult, if not impossible, to understand what is going on in a perceptual learning experiment by observing half an hour's performance. Certain vital parameters of the learning process function as fixed constants over a short period of time, and one can only assess their dynamic implications if one scans years of learning instead of minutes. Broad, sweeping changes take place in perception from early childhood to adult life. It is only by conducting experiments on perceptual learning at various age levels that our eyes compose a forest from the jungle of trees. Perceptions are not fixed from one year to the next, even though the child may be father to the man. Needs and motives urgently expressed by the child are relegated to obscurity in the adult; in-

centive values of various classes of reinforcement stimuli change, even as a child will run an errand for a piece of candy but an adult will demand other kinds of remuneration. Sometimes the change in needs is gradual, and sometimes it is dramatic in appearance, as when a boy at age ten snorts and avoids girls, whereas at age eleven he will do everything possible to attract their attention.

There are other equally good reasons for including developmental factors in a book on perceptual learning. It has long been explicit in psychoanalytic theory and implicit in most other psychological theories that perception and cognition are more closely knit with affective processes in children than in adults. Heinz Werner (65), Witkin (66), Murphy (38), Piaget (48), and many others have illustrated, both by argument and by experimental evidence, the plasticity of perceptual apparatuses and functioning in the earlier years. If the greater part of perceptual learning occurs in the earlier part of man's life, it is imperative to examine closely the perceptual changes that take place in children. There is a warning that goes with such an examination; it is difficult, and often impossible, to separate the nature and the nurture that underlies the evidence. We make no pretense to dissolve the tortuous intricacies of the nature-nurture problem, as they pertain to perceptual changes in children. However, whether perceptual changes take place as a normal part of a child's development or take place through specific learning processes does not detract from the value of examining such changes.

BEFORE THE CHILD LEARNS TO TALK— THE BEGINNINGS

Before a child learns to talk, we have to rely upon nonverbal behavior to make inferences about needs, motives, perception, and learning. As adults we often interpret children's behavior, during this stage of development, too much along the lines of our expectations of adults. An infant's mind is neither a *tabula rasa* nor the miniature of an adult's mind. He has certain inherited propensities for various forms of action, feeling, and perception, but to a large extent the infant is neither physiologically

nor psychologically complete so far as maturation and learning are concerned.

The reader may be curious as to why we chose the age of speech as a point of division in development. Children develop at different rates, and chronological age is, at best, a very rough indicator of the maturity of a child. The age at which a given child learns to use coordinated speech (at least short sentences) to communicate varies markedly. And speech, which is peculiarly human, is intricately interwoven with the general development of perception, meaning, thinking, and problem-solving. Sherif and Sherif (59) describe this interaction with remarkable clarity in their chapter titled "Man and His Words." At one point they write:

> A child's early words are closely tied to what he has seen, handled, used, and experienced in other ways. Like his perceptions, his first words are broad and undifferentiated. Like his perception of the world, the child's acquisition of words is selective, reflecting his desires and affective states. . . . While learning words is at first limited and regulated by the child's perceptions, his perceptions are, in turn, reacted upon by his acquisitions of concepts (59, p. 472).

There is, in short, little doubt that speech can mediate perceptual generalization, produce sets to perceive thus and so, express phenomenal experience to a degree unreached by any other response, and dictate what will be attended to in the world about us. For these reasons we chose this point as a reference point in development.

The infant lying in his crib cannot speak, but his behavior "speaks" for him. There is a great deal of sleeping; some restless, global activity, particularly when his diaper is soiled or he has been without food for some time; there is some ability to follow moving objects with his eyes; and by six months there is some awkward but directed reaching for seen objects. These behaviors, as keenly described by Gesell (14) and further elaborated in Gesell, Ilg, and Bullis (15), allow us to make certain inferences about perception and provide a partial answer to the question "Why do we see things the way we do?" (28). In order to

follow moving objects with his eyes, the infant must be able to separate the object as "figure" from its surrounds. Essentially the same inference is drawn by Hebb (21) from quite different evidence. Figure-ground differentiation is innate, and to a considerable extent we see "things" as "things" because of the way we are constructed by our heredity.

Spitz and Wolfe (62) would go even further. In their studies on the smiling response in infants, they observed that infants smiled at any humanlike face (even those with grotesque masks) more frequently than at other sources of stimulation. This might indicate an instinctive discrimination, the infants perceiving human faces as "things" which are potentially rewarding. This complex reaction to a complex stimulus strikes us as remarkably similar to the instinctual reactions reported upon by Lorenz (35), Tinbergen (63), and Pastore (42) in other species.

These so-called instinctual behaviors, as reviewed by Beach and Jaynes (1) and by Gray (20), are varied and seem to depend upon the occurrence of definite appropriate environmental conditions for their elicitation and growth. Of special interest to us are the studies on *Prägung*, or imprinting, a term proposed by Lorenz. There is a growing body of studies (*e.g.*, 20, 24, 25, 29, 30, 35, 63) on birds, cats, chickens, and human infants which indicates that there are critical periods in early development in which the parent or parent-surrogate is imprinted and in which to-be-feared things are imprinted. This imprinting is generally conceived as follows: At certain critical periods of early development the young animal has an innate disposition to learn to perceive something as intrinsically "good" (often its parent or parent-surrogate). If the young animal experiences a stimulus source that has the properties that "fit" this disposition, then that perceptual stimulus is imprinted. Imprinting takes place rapidly, often on the basis of a single experience, and is irreversible. The imprinting in turn leads to certain specific behaviors from the young infant toward the "parent" which "releases" other stimuli from the fixating parent. If there are no adequate stimulus sources present at the critical period in development, then the young animal will never imprint a parent. Imprinting is of special significance to us, since it is basically one-trial per-

ceptual learning, or at least rapid perceptual learning which takes place specifically at critical periods of development. In another sense, the term "perceptual learning" may be inappropriate since imprinting involves (*a*) the growth of critical biological, physiological factors within the individual and (*b*) the occurrence of the appropriate environment; in this sense, it might be better to speak of imprinting as one-trial "perceptual maturation."

An infant's behavior also indicates that he "attends" to certain events more than others. Moving objects, his mother, his toys, and animals are among the first attention-getting sources of stimulation. Gesell, Ilg, and Bullis (15) have noted a fixational response of the entire body of the neonate to visual stimuli, and particularly to moving objects and bright objects. In a rapid, unfolding sequence the infant comes to attend to his toys and his hands and feet. His hands open and shut as if he were grasping an object while he is just looking at it. With continued maturation, he integrates his tactual and visual perceptions of objects; the integration reaches full expression before the infant is five months old. The number and variety of things attended to increase with maturation (and learning?).

However, the infant is not able to make skillful focusing movements. Gesell *et al.* (15) also report that there is a great deal of trial and error, and more and more success, in fixating objects at a distance. The coordination of binocular convergence and accommodation improves in efficiency within the first few months, and doubtless this leads in turn to clearer reception of the world-at-a-distance, one of the goals of perception as described by Hilgard (22).

Moreover, studies on young rats (10, 12), ducks (49), and chimpanzees (54) in which usual visual experiences have been severely restricted indicate that normal, visual attentive acts as well as form discrimination are disrupted. Drever (9), in an ingenious twist, reversed Hebb's (21) technique of impoverishing early stimulation. By studying haptic perception of people who had become blind at various stages of development, he was able to show that impairment in haptic perception was negatively correlated with age at which blindness occurred. Blind persons who became blind at the earliest age were best able to recognize

pegboard patterns, the analogue of visual form perception. Drever's results also substantiate Révész's (53) observations that art products of people who became blind as adults are like those of nonblind people, but that the artistic creations of people born blind are less integrated and are exaggerated along the lines of non-Euclidean, haptic space.

Whereas all the above studies varied *omission* of some aspect or amount of early visual experience, other studies (*e.g.*, 19) have varied the *presence* of specific stimuli in the young animals' environment. Gibson and Walk (19) put drawings of several forms in the living cages of young rats. Later, when the animals were given form discrimination tasks involving those forms and others, it was found that the forms experienced in the living cage were most easily discriminated. These results are in accordance with Koffka's (27) thesis that the mind grows by the successive laying down of memoric traces which articulate with immediate perceptual traces in producing percepts. The *process* of perceiving does not necessarily change though the structure of percepts in awareness may be altered. The mind also grows by exercise which provides new experiences and memories, and growth can be stunted by preventing normal exercise just as a child has difficulty learning to walk, or a bird to fly, if prevented from carrying out certain exercises beyond crucial stages in development. If the mind grows by successive laying down of memory traces which articulate with subsequent perceptual traces to form new percepts (and memories), then early visual experiences and memories are clearly more important than later experiences.

This feature of Koffka's theorizing is central to the Gibsons' thesis although they approach perceptual development more from a learning position. The Gibsons' thesis (16, 17, 18) is that a *closer* psychophysical relation develops between stimuli and perceptual responses with experience and practice. Perceptual development moves toward psychophysical veridicality—an undeniable interpretation, but one that needs more explanation, since a child also goes through a stage in which autism and animism predominate in perception (47, 65).

All of the foregoing gives us some simple information. Before any perceptual learning takes place, the infant can perceive.

Whether or not the qualities or attributes of adult perception are present is not debatable, but it is debatable that perception depends *solely* upon learning. In a very strict sense, this informs us that *we do not completely learn to perceive nor is perception completely innate*, a point forcefully made by Zuckerman and Rock (67) in a recent reappraisal of the roles of past experience and innate organizing processes in visual perception. Most perceptual learning is more accurately labeled "perceptual modification." Some acts of perceiving exist prior to any restructuring. An infant can certainly differentiate figure from ground, discriminate complex stimulus sources, and attend to parts of his environment—in other words, the more basic aspects of perceiving are present.

The infant does not experience what William James called a "booming, buzzing confusion" nor is his perception completely vague and undifferentiated as Piaget (43, 44, 45, 46, 47, 48), Werner (65), and Vernon (64) among others would have us believe. In the sense that "meanings" are not attached to "things," perception is incomplete. There is a subtle difference between experiencing a chair as an entity and experiencing it as a chair, but it is an important difference. In Gibson's (16) words, there is a difference between the "literal world" and the "assumptive world" of an individual. Meanings certainly accrue to perception with development, but the infant's world of perception is not completely a hodge-podge, a confusion, or a blank tablet upon which experience writes. Just as motor learning consists, to a considerable extent, of refining response skills and putting an edge on already existing responses in the individual's repertoire, so does perceptual learning consist of sharpening and differentiating the perceptual acts which are given through heredity and maturation.

AFTER SPEECH— MORE GROWTH AND LEARNING

Once the child has learned to talk, we can ask questions and obtain partial answers as to how he perceives. In particular, we can more easily tell *what* he perceives. A vast amount of information

about perception is derived from speech behavior, both in and out of laboratory experiments, although other forms of behavior are observed, as in the adjustment method of psychophysical experiments. Piaget's (43, 44, 45, 46, 47, 48) basic paradigm is to ask children questions and to record their answers for analysis. However, our aim is not just to analyze language behavior or even to ponder psycholinguistics; instead, our aim is to present a theoretical picture of what happens to the process of perceiving in the development of the child. There has been a great deal of speculation about the course of development, and Table 3 summarizes some of the *major* points made by Piaget (48), Werner (65), Schilder (58), Bleuler (3, 4), Rapaport (50), and Lewin (34).

TABLE 3

Some major points made about developmental stages in cognition

AUTHOR	SEQUENCE OF STAGES
Piaget (48)	1. No distinction between self and experience. 2. Primitive, assimilatory schemata formed based on "I perceive—I move—Object moves—I perceive something different" circular reaction. 3. From second stage, magical beliefs arise that inanimate objects are alive, as well as superstitious behavior. 4. Child becomes aware of own actions, discriminates such from outside actions, and achieves more veridical perception.
Werner (65)	1. Perception is primitive and syncretic in infant. There is limited differentiation of object and subject, of perception and pure feeling, of idea and action. 2. Emotions (affects) become differentiated, and perceptual constancies arise to maintain drive satisfactions; actions as means and concepts arise as primitive meanings. 3. Synthetic modes of action, thought, and affect develop, *i.e.*, action, thought, and affect can interact after each has been differentiated by the child.
Lewin (34)	1. Infant's discrimination is poor or nonexistent. "My own body" does not exist as entity. Neither do future events or expectations. Child is ruled by immediate situation. 2. Cognitive areas acquire definite character, the first being centered around food and elimination needs. Needs are poorly distinguished. Child learns "my own body" which serves as reference point for learning immediate surrounds.

TABLE 3 – *Continued*

AUTHOR	SEQUENCE OF STAGES
	Primitive social relationships develop; needs organize behavior; derived needs appear. There is intense need, high level of irreality, and fluid (loose) cognitive structure which permits easy movement from reality to fantasy and return. 3. As quasi-needs develop, intentions (will) acquire status of quasi-need and thoughts about future develop. Cognitive structures become more articulated and differentiated, which prevents full impact of needs on perception.
Schilder (58)	1. Indefinite percepts. 2. These are transformed into definite percepts, images, and ideas by drives (needs) and the associated affect. Ideas stem from drive-cathected percepts. 3. As percepts become more definite they lose some of the drive cathexis and more veridical perception is attained, but thinking and perception are always vulnerable to pleasure-pain principle and to early affective ties.
Bleuler (3, 4)	1. Affect (the subjective aspect of motivation and drive) is inseparable from percept. Percepts are fragmentary. 2. Child becomes aware of discrepancy between his percepts and reality. 3. Child becomes aware of relationship between his subjective experiences of affect and his perceptual experiences.
Rapaport (50)	1. Infant has certain givens: primitive perceptual apparatuses, tensions, and capacities for affect and affect discharge. The primary models of *action*, *thought*, and *affect* (see Rapaport for details of models) operate simultaneously. This leads to close relationship between these three, *e.g.*, with increase in need infant will partially discharge need through hallucination of need-object. 2. Ideas are now drive representations; memories and ideas are organized around drives; and primary process thinking is evident. 3. As child learns more means to goals, a *connectedness along pathways in reality* toward need-satisfying objects forms basis for reorganization of ideas. Child partially acquires independence from original drives, and secondary process thinking arises.

We shall refer to this table from time to time in our presentation, but we cannot go into each position separately. Instead, we shall attempt to present an *integrated* picture of perceptual (and cognitive) growth which seems sound and reasonable to us, our own position being an eclectic one which embraces some of all

these men's beliefs. In addition, we are indebted to Karl Buhler (6), Freud (13), Gesell, Ilg, and Bullis (15), the Gibsons (16, 17, 18), Koffka (27), and Michotte (36) for many stimulating ideas. In brief, we have taken the eclectic's prerogative of freely drawing from evidence collected to support radically differing theories; we also have the eclectic's burden of presenting an integrated point of view. This can, perhaps, best be done by tracing major and minor trends in perceptual development.

A MAJOR TREND

The child in infancy has the basic ingredients of the perceptual act, but relatively vague and undifferentiated percepts. He then accumulates autistic percepts to a considerable extent, followed by a reduction of autism and an increase in veridical percepts. This is the essence of the summaries given in Table 3. The problem at hand is *how* and *why* this particular sequence of development. What produces autistic perception and what leads to the development of more veridical percepts?

Though the young child does have some attentional capacity (15), the number of stimuli which can elicit attentive acts is quite restricted; he also has intense affective reactions; his affect-control behaviors are almost nonexistent and he is compelled to discharge his tensions immediately. It has also been suggested (11, 50, 58) that this reduction of tension can take place in the infant by hallucination-like percepts. The internal stimuli produced by motivating stimuli (S_m) form a large part of the perceptual field. Perceptual stimuli such as the child's parents, his toys, his pets, and his immediate surrounds can easily become conditioned stimuli which evoke emotional-affective responses. These mechanisms would lead to percepts associated strongly with affect. The child's low level of awareness of being autistic is perhaps indicative that classical conditioning of perceptual stimuli to affective responses has occurred, along the lines indicated by Razran (51). As a consequence of early learning experience, a large number of perceptual stimuli acquire *both* secondary motivating and/or secondary reinforcing characteristics. In this regard, an autistically structured percept is one which is

motivating and/or reinforcing. The ugly problem raises its head as to why the child should ever extinguish or give up autistic percepts since they have such properties.

Ferenczi (11) makes some intelligent suggestions on this problem. He writes: "We note how the omnipotence of human beings gets to depend on more and more 'conditions' with the increase in the complexity of the wishes. These efferent manifestations soon became *insufficient* to bring about the situation of satisfaction. As the wishes take more and more *special forms* with development, they demand *increasingly specialized* signals" (11, pp. 224–225). [ITALICS OURS] The words are psychoanalytical but the expressed ideas can be fitted into our system. What is suggested is (*a*) that autistic percepts are only partial satisfiers and needs continue unabated in large measure and (*b*) that there is a differentiation and elaboration of needs, as we have defined need, with development. Both of these mechanisms are implicit in Rapaport's explanation (50) of development.

The failure of autistic percepts to offer complete satisfaction arises perhaps from the fact that there is extinction of the emotional-affective response associated with a perceptual stimulus. This could come about by a change in time relations between percepts and ultimate reinforcement, such as longer delays between being hungry and getting food, between wanting a toy and playing with it, and so on.

The differentiation and elaboration of needs implies that the acquisition of secondary motivations and reinforcers leads to new goals, to new experiences, and to greater frustrations due to changes in parent-child-environment relations with age. This is in agreement with the Freudian principle that conflict is necessary for psychological growth (13). Conflicts between wishes and reality, between needs and ability to control need-produced affect, and between various aspects of reality serve to produce motivation for change from autistic forms of perceptual organization to more veridical forms.

There is still a third possible "explanation" of the dynamics of the developmental sequence of "primitive perceptual acts–autistic dominated stage–veridical stage." It is thoroughly plausible that the basic ingredients of learning—namely, contiguity (or time

factors), reinforcement (positive and negative), motivation, and practice—carry different weights in influencing "literal" and "assumptive" perception. The Gibsons and Hebb are clearly invoking the principles of contiguity and practice in explaining the achievement of more veridical *literal* perception, whereas Piaget, Werner, Schilder, Rapaport, Lewin, Freud, and Ferenczi are clearly invoking the principles of contiguity, motivation, and

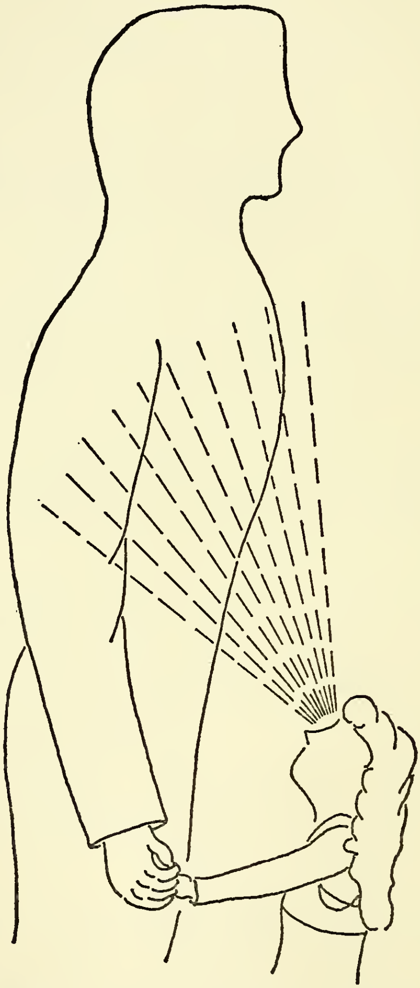

FIGURE 7. *Child's-eye view of father.*

reinforcement in explaining the development of autism. It is possible that there is no inherent contradiction. If so, *both* autistic and veridical development can go on independently, to a large degree, of one another. Autism and veridical perception *can* be reflected in exactly the same perceptual structure, as noted by Rapaport (50) and Schilder (58). The child may perceive his father as a powerful, friendly giant who takes care of him. From the child's position, the planes, edges, surfaces, spots of light on a curved surface, etc., which constitute the complex stimulus source called "father" *are as if they were from a giant.* Figure 7 illustrates this point. However, the affective and meaning component—the "assumptive" aspect of "father"—may reach such proportions of love or fear that the child perceives his father as a god capable of completely satisfying or denying his every wish.

Some Specific Trends

There are several specific long-range trends in perceptual development. There is a shift from "field dependence" to "field independence" (66), a shift in the relative effectiveness of the Gestalt laws of visual organization (56), and a shift in the impact of rewards and punishments upon figure-ground organization (57, 60, 61), among others.

The Development of Field Independence. A large debt is owed to Witkin and his co-workers (66) for their extensive contributions to experimentally acquired knowledge in this area. These investigators were not looking explicitly at the problem of perceptual learning; instead, they were looking for individual consistencies in various perceptual tasks as an integral and developing part of the individual's personality. We could add little to what Witkin and his colleagues have said if we looked at their data solely in terms of individual differences or intra-individual consistencies. But their data are rich in implications for a general understanding of perceptual development.

Although Witkin *et al.* (66) have demonstrated several broad trends in perceptual tasks as a function of age, the most striking trends are present where the individual has to extract one part from a dynamically interrelated field of stimuli. Children be-

tween eight and ten years of age perceive an item very largely in terms of its surrounding context; between ten and thirteen there is a marked decrease in the influence of the surroundings; between thirteen and seventeen there are still further decreases; and after seventeen there is a slight return to some context influence. Figure 8 is taken from Witkin *et al.* (66) to illustrate this trend. Though this figure shows the trend in mean time required for extraction of a form from a Gottschaldt design (Embedded Figures Test), the same trend is to be observed in similar tasks.

Essentially the same kind of results come from the rod and frame test and from other tests that involve a separation of field

FIGURE 8. *Mean scores for embedded figures test for various age groups.* (Modified after Witkin *et al.* [66].)

events. These studies demonstrate the long-range trend for perceiving stimulus sources independently of one another. Similar conclusions are drawn by Piaget (47) and Werner (65) who noted that young children often function concretely and syncretically. A young child perceives his father as "father" or his mother as "mother" only in concrete situations, and only gradually develops a percept of his father or mother which is independent of specific contextual surrounds. With growth there emerge more constant percepts, and contiguous stimuli exert less influence on the structuring of a percept. With growth, a larger degree of perceptual freedom emerges.

The Determination of What Is Figure. In a certain sense the figure-ground problem is also an embedded figure problem. If a form is to stand out relative to the ground on which it lies, it must be extracted. In order to extract a form from an embedding context the individual must scan the context, focus his attention on the form and make the form serve as figure and the remainder as ground. On the other hand, when the individual sees one aspect as figure and the other as ground, he tends to hold on to the figure. As observed in younger children, there is an innate organization of figure and ground relations. However, what is to be figure and what is to be ground are determined by specific learning experiences as well as the way in which our nervous system is constructed.

We can put together the results of several studies and get a partial answer to the relationship between perceptual learning and age as related to the figure-ground problem. The Schafer-Murphy paradigm, which is discussed in detail in Chapter 12, has been repeated with several variations in reward and punishment procedures, with children of various ages, by Solley and Sommer (61), Solley and Engel (60), and Santos (57). Both the effectiveness of learning conditions and the direction of the resulting perceptual figure-ground changes are a function of age. In all of these studies, the rewards were winning money and the punishments were losing money. Children between five and eight years of age perceived more "autistically" than older children; they organized the figure-ground compound stimulus so that the rewarded figure in a reward-neutral and a reward-punishment, or

the neutral figure in a punishment-neutral condition, was figure. Children between nine and twelve years of age showed little or no effect from the rewards and punishments, though the children who appeared to be strongly involved also showed an "autistic" effect (57, 60). Young adults (23) on the other hand tended to emphasize the punished aspect in a punishment-neutral condition. These general trends are shown in Figure 9.

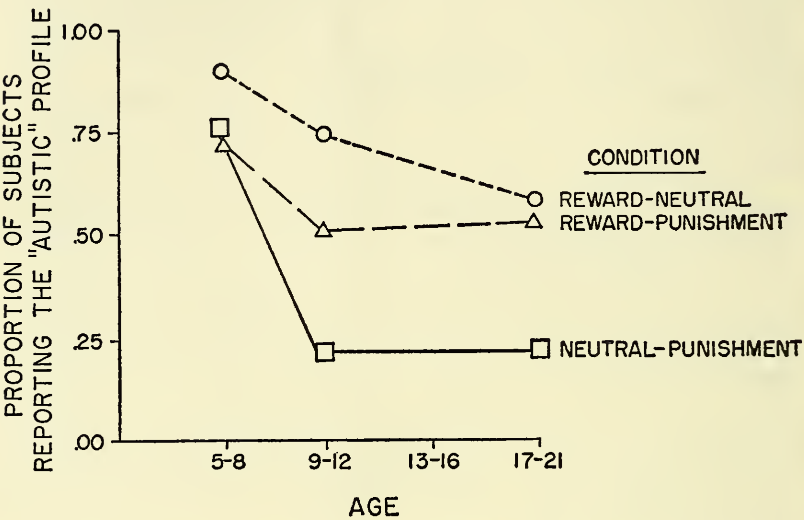

FIGURE 9. *Proportion of subjects organizing ambiguous test figure in an "autistic" manner as a function of age.*

Figure 9 shows the drop in "autistic" mode of organization and the increase in "vigilance" for mild punishers and rewards with increase in age. The child moves away from simply seeking pleasure and avoiding pain to being alert to mild punishers, particularly as he acquires behavioral means for dealing with punishment stimuli.

The younger children (61) also showed a great deal of fantasy connected with the profiles. They nearly all consistently refused to call the profiles "faces" but referred to them as "moons" or "men in the moon." Their comments, which were unsolicited,

reveal that affect was cathected to the faces, especially those for which they were rewarded. One little boy commented, "Clem's a bright moon, like the man [laughs] in a full moon." With this boy Clem had been rewarded in the training phase. Another for whom Jake had been rewarded said, "Jake looks kind of happy. He's smiling, as if he's smiling. Here you look. [*E* looked.] Don't you think he's happy?" Another: "Clem's a big fat moon." And another: "Both moons are there, only Jake has a line drawn around him with a heavy pencil." These spontaneous comments recorded by Solley and Sommer (61) were corroborated by answers to leading type questions. The children between five and eight years of age perceived the rewarded face, compared with the no-reward face, as happier, brighter, having a darker line drawn around it, and nearer to them. Solley and Engel (60) also found similar results with children between five and eight years of age.

Children between nine and twelve (60), on the other hand, yield fewer spontaneous comments and less consistent results in answers to questions concerning the properties of what they perceive. To a significant degree, they perceive the rewarded profile as happier in a reward-neutral or reward-punishment condition, and a neutral profile as happier in a punishment-neutral condition. Although adults in the reward-punishment condition (23) sometimes refer to the punished profile as a "goof" or an "idiot," it does seem that adults cathect far less affect to perceptual stimuli in experiments than do children.

Indeed, the whole basic premise of the formation of autistic perceptions rests on the assumption that affect is cathected. An autistic perceptual organization is basically one in which cathected or immediate affect invades perception to such an extent that the individual is swayed from perceiving veridically. From the evidence which exists—and it is indeed scanty—it seems that the major reason why children function more autistically than adults in their perceptions and cognitions lies in the lability of affect and the degree to which it becomes attached to percepts. Piaget, Werner, and others have stressed the function of affect in the magical ideas and autisms of children and primitive groups.

The trend which we have been describing seems complex.

However, the trend is fairly simple. It can be summarized as follows: with young children, a simple pleasure-pain principle predicts what will be organized as figure in a figure-ground learning experiment; but with increase in age, mild punishers acquire attention-getting properties (60), particularly as the child develops affect-control behaviors. With Klein (26) and Lois Murphy (40), we contend that the development of behaviors which cope with, modulate, or regulate affect are of paramount significance in determining the extent and direction of cognitive development. At least this hypothesis is supported by experimental studies of perceptual learning in which figure-ground organization has been studied (57, 60, 61).

Changes in "Laws" of Visual Organization. Another long-range trend has been studied, experimentally, by Grace Rush (56). The classical Gestalt laws of visual organization, as described by Koffka (28), are often presented as unchanging; yet the laws of proximity, similarity, common fate, and so on, as known in adults may change progressively with age. Rush studied children and adolescents between about six and twenty-two years of age (the first grade through college). She presented simple dot patterns which could be organized in one or more ways and determined which method of visual organization was dominant. Her results cast doubt upon the "unchanging" nature of visual organization, since the efficacy of continuity, similarity, proximity, and direction as principles of visual organization change with age. Continuity of patterns increases in efficacy up to about fourteen years of age and then drops off to a lower level. Similarity and proximity both steadily increase in efficacy with age. And there is a shift from seeing equally spaced dot patterns as rows to seeing them as columns—a shift from horizontal to vertical emphasis in visual organization.

Rush's studies do not tell us how these changes in visual organization take place; we are left in the dark as to possible mechanisms. Such changes could take place through several processes. The child may be reinforced, by his societal group, for perceiving certain patterns rather than others; the language that the child learns may be readily capable of expressing certain visual patterns but not others; the child may simply experience

different sensory groupings with age and his "laws" of visual organization may simply reflect differential experiences and differential rates of neural maturation which take place at various age levels; or some of the changes may be due to changes in "field independence-dependence" as noted by Witkin and his collaborators.

Changes in Perception of Causal Relationships. Between birth and about twelve years of age there are radical changes in how children perceive cause and effect relationships. These changes are most vividly and thoroughly described by Piaget in *The Child's Conception of Physical Causality* (45) although Michotte (36, 37) has also made considerable contribution to our knowledge of how children perceive causal relationships.* In general, there is a shift from primitive, phenomenological causal relationships to more and more rational forms. In the early stages of development causality is "teeming with subjective elements. No distinction is drawn between motivation and physical causality or between muscular and manual activity and mechanical action, or again between the influence of mind on body or of the body on itself" (45, p. 267). Piaget postulates three processes which underlie the evolution of perceived causality. These are: (*a*) the de-subjectification of causality; (*b*) the formation of stable series in time; and (*c*) the progressive reversibility of cause and effect. The first process is the shifting of causation from the realm of pure phenomenology to the occurrence of specific externally perceived agents. The second is the discrimination of events in time and the discounting of sheer contiguity in time as an agent of causation. The third process is the building up of more abstract "feedback" concepts of causation. (Piaget does not describe the process in this way, but this phrase seems more appropriate to us.) These processes come to fruition when the child is about eight years old; indeed, Piaget asserts that true perceived causation as adults know it does not exist prior to about that time. This claim bears the support of Lacey and Dallenbach (31) and Olum (41), although Michotte (36, 37) would disclaim it.

* An English summary of Michotte's work can be found in Vernon's excellent book (64).

Michotte asserts that simple cause and effect relationships are directly perceived without benefit of experience or learning. However, the argument is almost purely one of language. Piaget used an adult's frame of reference in describing the development of perceived causation. When he describes, elegantly, how a young child perceives moving things as alive and contiguous things as causal, *e.g.*, the one ball sinks in the water because it is white and the other ball floats because it is black, he is assessing the child's perception of causation in terms of the adult's frame of reference. Michotte, on the other hand, uses a phenomenological frame of reference and relates perceived causality to immediately obtaining field conditions. When one considers the difference in reference points, there is no disagreement at all.

VALUES, NEEDS, AND PERCEPTION IN CHILDREN

There are numerous studies in which children have been observed as subjects, but which do not connect readily with any of the major and minor trends that we have discussed. Some of these studies are particularly pertinent to any consideration of perceptual learning in children and can scarcely be omitted. For example, Bruner and Goodman (5) stirred up a hornets' nest when they reported that poor children perceive coins as larger than do rich children. Carter and Schooler (7) were not able to obtain the same result, although they were able to show that size estimates of coins *from memory* were larger for poor children than for more wealthy ones. The difficulties inherent in the designs used both by Bruner and Goodman (5) and by Carter and Schooler (7) are enormous. Poor and rich children tend to differ in many ways other than in just the income of their parents, and the amount of experience with spending money is certainly uncontrolled.

Fortunately, a simple and clear-cut experiment was forthcoming. Lambert, Solomon, and Watson (33) used a simple technique of having an experimental group of nursery school children turn a crank on a gadget ten times to receive a white poker chip, which could be put into another machine to obtain candy. A

control group received the candy directly. Size estimates of the two groups differed, with the experimental group overestimating the size of the poker chip. The overestimation increased with more and more reinforcement. When the poker chips were not given, during extinction, the size estimations of the two groups quickly converged to the control group level. A repetition of this experiment (32) with some elaboration produced the same results. From these perceptual learning studies we can draw the conclusion that reinforcement associated with a stimulus source leads to an overestimation of size, with the caution that this may work only when the judged stimulus target "fits" into some schema in which value and size co-vary positively, as value and size of coins tend to do in our culture (8).

In addition, Rigby and Rigby (55) have shown that letters which have been indirectly reinforced with candy are perceived at lower tachistoscopic thresholds than are letters which have not been associated with reinforcement. We know of no adult research in which adults have shown lower thresholds for rewarded stimuli than for neutral stimuli. Perhaps children's perceptions can be altered much more easily by rewards and punishments than can adults'.

SOME AFTERTHOUGHTS

Perceptual development is complex, and it appears impossible to interpret perceptual changes in terms of maturation alone, or in terms of learning alone. We have seen instances, as in the case of imprinting, in which early learning opportunities articulate with highly specific maturational dispositions to alter perception. This seems to be the most general principle we have found; perceptual learning is dependent upon the level of maturation achieved by a child, and conversely the full achievement of maturation can be facilitated or inhibited by the occurrence or nonoccurrence of specific learning experiences. Neither maturation nor learning can fully unfold independently. We see "things" the way we do as adults largely as a resultant of the interaction of nature and nurture within the context of our culture.

SUMMARY

Before any perceptual learning takes place, an infant can perceive. An infant certainly can differentiate figure from ground, can discriminate between certain colors, tastes, odors, and other sense data, and can attend to parts of his environment. The basic aspects of perceiving are present, although the infant's perceptual world is certainly not as rich or complex as an adult's.

The perceptual development of infants and children is complex, and it appears impossible to interpret perceptual changes purely in terms of maturation or in terms of learning. We have seen instances, as in the case of imprinting, where early learning opportunities articulate with highly specific maturational dispositions to alter perception.

This seems to be the most general principle we have found: Perceptual learning is dependent upon the level of maturation achieved by a child and, conversely, the full achievement of maturational potentials can be facilitated or inhibited by the occurrence or nonoccurrence of specific learning experiences. Neither maturation nor learning can fully unfold independently.

In developing perceptually, a child goes through long-range trends. At an early age he develops an autistic mode of perceiving, largely because his earliest percepts are associated with affect. In time this mode of perceptual organization is extinguished or unlearned and a more realistic mode is acquired largely by progressively finer perceptual differentiations. There is also a long-range development of field independence as well as changes in field organization.

In summary, we come to see "things" the way we do as adults largely as a result of both maturation and learning which takes place within the context of our culture.

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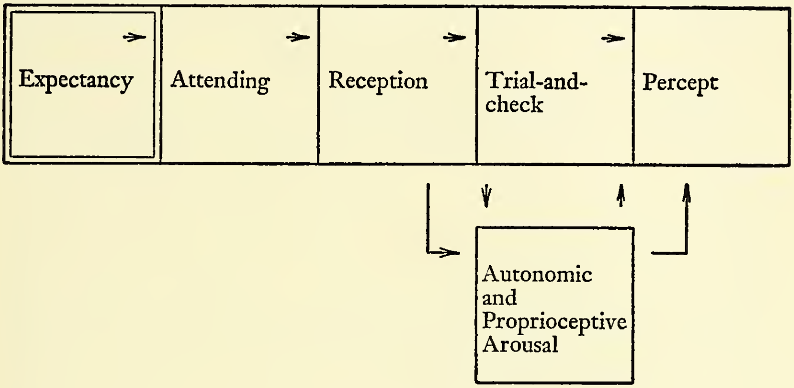
II

Changes in the Perceptual Act

We have now examined and evaluated the role of several basic learning mechanisms in perception. We have also presented a concept of perception; and we have noted that the term "perception" is used to refer to both process and product. "Perceiving" is the process by which products called "percepts" are structured. "Perceiving" was analyzed as an *act* which restructures the perceived environment just as a motoric instrumental act restructures the physical environment. The perceptual act was further analyzed into stages, although it was recognized that these stages do not exist as cut and dried way stations to the final structured percept. These stages were briefly described in terms of: (*a*) expectancy, (*b*) attending, (*c*) reception, (*d*) trial-and-check, (*e*) autonomic and proprioceptive arousal and feedback providing additional stimuli, and (*f*) structured percept. We must now examine the impact of learning upon each of these stages of the perceptual act.

3

The Development of Perceptual Expectancy



In our formal analysis of the perceptual act the first component (after some degree of "readiness") was expectancy. It is proper and orderly, therefore, to consider (*a*) the role of perceptual expectancy in the perceptual act and (*b*) the alteration of perceptual expectancies through learning. The former problem has long been recognized as important for understanding perception. Indeed, the problem of perceptual expectancy has been recognized since the days when Helmholtz proposed the term *unbewusster Schluss* or unconscious inference. It has been called various things—unconscious inference (Helmholtz), set (All-

port), hypothesis (Bruner and Postman), and perceptual expectancy (Solley, Jackson, and Messick). The names change but the phenomenon remains the same. The essential idea is a simple and reasonable one: we perceive more readily and more clearly those events we expect to perceive.

As we have formulated the matter elsewhere: "Except in the newborn there is always, as a result of past experience, some anticipation of what a given situation may portend; every situation is somewhat like some previous situation which had implications for the organism" (30). This comes about, if for no other reason, simply because aspects or objects of the world which constitute perceptual activity are not equal in occurrence, in distribution, or in significance to the organism. Brunswik states this point: "Generally speaking, both the object-cue and the means-end relationships are relations between probable partial cues and probable partial effects. . . . Cues as well as means can be ranked into 'hierarchies' in accordance with the degree of probability by which they are linked" (7). The array of potential stimuli which make up the visual world is ecologically distributed as a "causal texture" (40) such that partial information at one moment imparts partial information as to what aspect of the environment will be encountered next. In information theory terms there is a redundancy of environmental information which an individual utilizes in anticipating environmental events (15). Use of such redundancies allows the individual to prepare himself better for satisfying his needs.

It should be added, parenthetically, that modern probabilistic models of motor learning (*e.g.*, 9, 11) explicitly calculate the expectancy system of probabilities of eliciting various classes of behavior. These models have in common the postulates (implicit or explicit) that stimulus sources vary in their potential of being sampled, that the response system is a probabilistic one, and that learning consists largely of developing probabilistic expectancy relationships between these probable sources of stimulation and probable forms of action. These new trends in learning theory seem, at last, to bind the organism to the environment and the environment to the organism.

As hinted in the foregoing introduction, we lean strongly to-

ward Brunswik's probabilistic functionalism and its closely related cousin, transactional theory. The transactional school of thought, composed of such men as Ames, Cantril, Kilpatrick, Ittelson, and others, explicitly favors the Helmholtzian doctrine of unconscious inference as well as the functionalism of Dewey and Bentley. Kilpatrick writes:

> An early definition of ours put together by Adelbert Ames stated that "a percept is a prognostic directive for purposeful action." . . . It is our conviction that the perceptual organization of the moment cannot be an absolute revelation of what *is*, but is instead a sort of "best bet" based on past experience. This "best bet" based on the consequences of past dealings with our environment is expressed in awareness as perceiving, and serves as a directive for further dealings with the environment (23).

The major problem to be dealt with in this chapter is this: How does this "best bet" come about; what are the factors influencing its development; and how does expectancy enter into the perceptual act? An initial examination of studies which deal with this problem reveals *two* distinct, operationally different, kinds of expectancies. *Before* a stimulus is presented in an experiment the individual is expecting to perceive such and such a class of stimuli. Some studies clearly deal with perceptual expectancies or, in Bruner's terms, with perceptual hypotheses, prior to the occurrence of a perceptual stimulus; and these operations are related to subsequent perceptual effects. The second group of studies clearly deals with what Woodworth (44) called trial-and-check. This is the phase of the perceptual act *between* occurrence of the perceptual stimulus and the full structuring of the percept in awareness. Here the investigators examine the changes in expectancies, inferences, or hypotheses which occur in the presence of the perceptual stimulus, but before the percept is achieved and particularly before the percept is fully in the awareness of the observer. In this chapter we shall deal only with the first group of studies, reserving the second group with its attendant problems for Chapter 11. We do not imply by this separation that the two kinds of perceptual expectancy are func-

tionally dissimilar. The two groups of studies are definitely dissimilar operationally, and that is all we mean to imply by considering them separately.

The studies on perceptual expectancy prior to the occurrence of a perceptual stimulus fall, in turn, into two broad categories. Some studies are concerned with the experimental learning of perceptual expectancies and some are concerned with the general effects of complex variables such as *Aufgabe*, *Einstellung*, sets induced by instructions, and so on.

THE ACQUISITION OF EXPECTANCIES

We human beings seem to seek or search for specific forms of stimulation, *e.g.*, a chair to sit on, a symphony to listen to, a dish of ice cream to eat, and so on. We scan our immediate environment in this search, or we may "locomote" (26) about changing the relationship between the environment and our sense receptors. In this perceptual search our actions are *not* random. We attend to this, then that, then something else—our attention shifting rapidly but not completely without order. We would not look for ice cream in a barber shop, a symphony while playing a juke box, or a chair in the middle of a creek. We know from countless acts of commerce with our environment that we can expect such and such a stimulus to follow or occur with another set of stimuli. Often before a given stimulus source can act as an input to our receptors, we are expecting it. The ebb and flow of experience is such that we are constantly being bombarded by stimuli, and it is only by developing expectancies and schemata that we are able to deal effectively with this array of stimulation.

Functions of Perceptual Expectancy

From the evolutionary point of view, the ability to develop expectations and schemata serves a useful function which, in the long run, enhances the likelihood of survival for the kind of organisms which we represent.

The functions of expectancy may be broken down as follows: (*a*) It narrows the possible modes of action, just as choice reaction time between two alternatives is quicker and more efficient

than reaction time between ten alternatives. (*b*) Expectation sometimes enhances the likelihood of our doing things which will bring us into commerce with the goal-objects to which our needs direct us. William James (20) had this in mind when he said that sometimes wishful thinking produces behavior which actually makes the desired event more likely to occur. We ready the environment, so to speak, by our expectancies, and in terms of any conception of learning this would stack the deck in favor of our receiving what we expect to perceive. (*c*) Expectancy may be directly self-rewarding in some cases, just as it is pleasant for a child to entertain an expectancy of Santa Claus. (*d*) Expectancy leads us to endure hardships, to stretch out time, so to speak, before reaching goals. Thus expectancy readies us not only for the good but also for the bad.

There are constant trial-and-checks between our expectancies and what we grasp perceptually at the moment. In expectancy situations, therefore, *feedback* is the very essence of the process. What we are doing is cutting down on the alternatives of final perceptual organizations open to us, trying to confirm some and perhaps add new ones to the total range of possibilities. When we carry out activity of this sort with our eyes, we create, as Gibson (14) would say, a visual world as contrasted with the visual field. Overlapping and articulating snapshots and motion pictures, so to speak, are arranged in orderly form, and memoric and imaginative materials rich in their own expectancies and redundancies give a sort of master expectancy or half realized schema to be completed on an all-or-none basis in perception.

Expectancies and Environmental Probabilities

Human beings are surprisingly sensitive to the probability of occurrence of stimuli. Brunswik (6) estimated that rats could not discriminate less than a 75:25 split in probability from chance occurrence (or from 50:50 occurrence), but Messick and Solley (29) found that three- and four-year-old children could discriminate more accurately than that (see Figure 10). And Hake and Hyman (15) have observed sensitivity in adults for the sequencing of stimuli. In their study, subjects were presented with a series of horizontal and vertical bars of light. The series varied

as to relative frequency of the two bars of light and as to the one-step conditional probability of the same bar of light following itself. Their results showed that subjects come to guess or expect perceptual events proportionate to the input parameters, suggesting that adult human subjects have a remarkable sensitivity to the ecological distribution of perceptual events in their environment. The development of veridical perceptual expectancies takes place rapidly and is facilitated by increased redundancy in occurrence of stimulus events. The individual is certainly able to map samples of his environment into patterns of expectancies.

Messick and Solley (29) present data which corroborate these points with children. Some of their data are shown in Figure 10.

These investigators used cards with drawings of kangaroos, horses, and stickmen, varying the relative frequency of big and

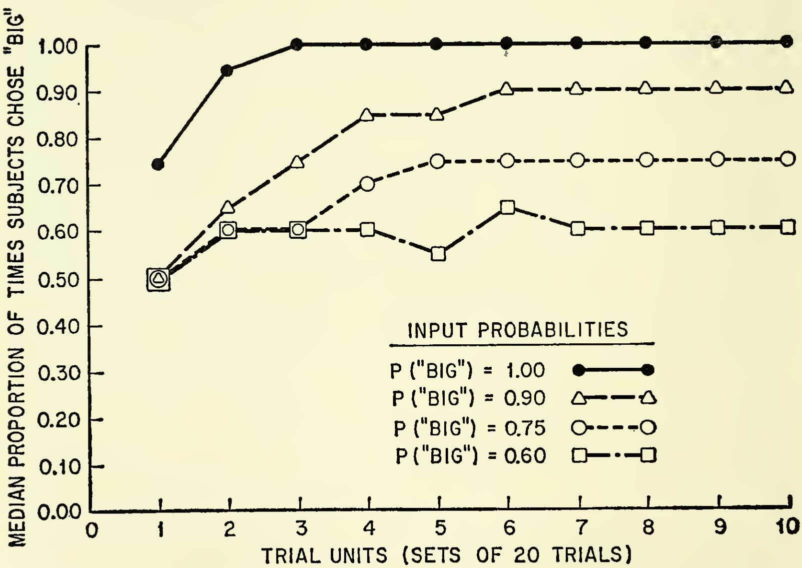


FIGURE 10. *Mean probability learning curves for four stimulus input probabilities,* i.e., *proportion of times "big" figures were presented, for seven children between three and eight years of age inclusive.* (From Messick and Solley [29].)

little drawings of each. A sample of children between three and eight years of age inclusive guessed whether the next card would show a big or little figure. Figure 10 shows the results. The younger children showed a lower rate of development of accurate perceptual expectancies, but not too much slower. This small difference could easily be accounted for by the fact that the younger children often stopped, played, or ate apples while doing their guessing. The children were intensely motivated. One little girl, age eight, stopped near the end of one series and said, "I know how to be accurate most often. I only need to guess the big kangaroo all the time. [This one was occurring most frequently.] But that wouldn't be any fun." She knew how to maximize the probability of being "correct" most often, but the guessing was like a game of trying to outwit the experimenter and she was having too much fun to try some other strategy in guessing. It should be added that this same little girl did quickly maximize the probability of being "correct" in her expectancies by guessing the most frequently occurring event all the time in a subsequent study where candy was given as a reward.

One might conclude, erroneously, that the probability or frequency of occurrence of stimuli is the sole determinant of perceptual expectancies, with the added caution that motivations can somewhat alter expectancy. The more frequently a stimulus event occurs, the more we expect it. However, this is only partially true. We also come to expect the *least frequent* stimulus under some conditions. This is usually called the "gambler's fallacy" (21). A simple study by Jarvik (21) illustrates this. In his study, college students were instructed to mark, on a sheet of paper, which of two alternative symbols, a check (√) or a plus (+), was going to be shown to them next. After making their marks, one of the two symbols was shown, and the subjects guessed what was going to be shown next, and so on. Jarvik used several series in which the probability of "checks" was varied. Although the symbols were randomized in a given series, runs occurred (in any random series, runs are bound to occur). He analyzed his data in terms of these runs. As the number of "checks" in a run increased, the probability of sub-

jects guessing (expecting) a "plus" to occur next *increased.* This is like flipping a coin and having "heads" come up five times in a row; people will nearly always expect "tails" to come up on the sixth flip although the probability is still 50:50. This is known as the gambler's fallacy. In short, the least probable event may be the expected event if it is possible and if it has not occurred for some time.

Corroborative evidence for this is given by Brunswik and Herma (8), although their study dealt with another problem. They developed a weight illusion through the establishment of expectancies. Noting that a heavy weight feels heavier if it follows a light weight and conversely, Brunswik and Herma varied the probability of light and heavy weights following one another. For the weights lifted with the left hand the series of weights was the opposite of the weights lifted with the right hand. Two weights were lifted, one with each hand, on each trial. Test trials were inserted in the series in which the two weights were both light or both heavy. The subject reported which felt heavier. With practice, the subjects learned to perceive a difference in the weights on the test trials, the amount of misperception depending on (*a*) the probability of weights shifting from heavy to light (or light to heavy) and (*b*) the length of practice.

A word of summary is in order. Human beings have proven themselves surprisingly sensitive to the environmental probabilities of stimulus events. Perceptual expectancies seem to reflect just about the same amount of information as is contained in the things they represent, even reflecting information about the temporal sequencing of environmental events. Expectancies seem to provide a fairly reliable and valid map of a vast number of perceptual events which the individual will encounter. In this sense expectancies allow the individual to project the past into the future, to ready himself for alternative classes of percepts, and to guide his search behavior (10). If he does encounter incongruous stimulus combinations, such as red spades and clubs and black hearts and diamonds on playing cards (5), his expectancies may override the immediate stimulus factors, or fuse with them, or produce bewilderment and delay in reporting.

The Role of Rewards, Punishments, Needs, and Valences

Besides the sheer probability of occurrence of perceptual stimuli, there are several other important variables which influence perceptual expectancies. Expectancies develop according to the *consequences* of perceptual organization. Some percepts are associated with rewards; others, with punishment; some are signals for avoiding noxious stimulation; some have acquired valences or values; and some work more directly with satisfying needs than do others.

Several quite different techniques have been used in studying the "valence" or incentive value of different rewards in influencing expectancies. Irwin (17) and Marks (27) had their subjects guess whether the next card they would draw from a deck lying face down on a table was marked or not marked. The relative frequencies or probabilities of obtaining a marked card varied from deck to deck. These probabilities ranged between .10 and .90. Subjects received points if they drew a marked card regardless of what they had guessed and lost points if they drew an unmarked card. They both found that the subjects guessed they would draw far more marked cards than unmarked ones, clearly overexpecting the cards with the greatest reward value.

Another technique was used by Jessor and Readio (22) who had their subjects guess whether they were going to hit a dart target hidden from view or whether they were going to pull a correct switch on a four-choice electric light panel. For different groups of subjects they used one, two, or three candy M&M's (for children) or a nickel or dime (for college students). They found no significant difference in the stated expectancies of hits with the darts. (They pointed out that the difference in incentive values might have been too small.) With the adults, however, they found that the subjects overexpected the events that had the greatest reward value. In both Jessor and Readio's study and Irwin's (17) study the greatest effect of incentive value was found when the input probability of actual occurrence was .50. Apparently the influence of different incentive values is greatest when there is some uncertainty and outcomes are neither perfectly predictable nor nearly impossible.

Still another procedure was used by Solley, Jackson, and Messick (38). These investigators had adult subjects associate symbols of rewards—*i.e.*, lights going on, objects being moved toward the subject, arrows pointing up—with one facial profile and symbols of punishments with the drawing of another facial profile. After this training, each subject guessed which of the two profiles was going to be exposed next from the top of a deck of cards in which the profiles were randomly distributed for each subject. They found that the subjects significantly overguessed or overexpected the profiles which had been associated with reward symbols. Indeed, several subjects, when told after the study that the two profiles occurred equally often in the deck, refused to believe the experimenters and made them count the cards for them!

The major conclusion one is led to draw from a sample of studies in this area is that people tend to develop strong expectations for the "good" and tend to underestimate the occurrence of the "bad." * Allport (1) makes this point a crucial fulcrum in explaining how rewards and punishments enter into perceptual structurings and perceptual learning. He argues, quite elegantly, that rewards and punishments change our expectancies or sets for various perceptual occurrences, and that when placed in an ambiguous or impoverished stimulus situation with inadequate sensory information we structure our percepts in accordance with our perceptual expectations.

Bruner (4) and Postman (32) also develop this hypothesis as a major point in their theories of perceptual learning. Postman's own words provide the best illustration of this when he writes:

> Central to our analysis is the concept of *hypothesis*. By hypotheses we mean, in the most general sense, expectancies or predispositions of the organism which serve to select, organize, and transform the stimulus information that comes from the environment. A given sensory input has not only energy characteristics which trip off a series of organized

* Hope springs eternal in the human breast:
Man never is, but always to be, blest.

Alexander Pope, *Essay on Man.*

> reactions in the nervous system, but it has cue or clue characteristics as well—it carries *information* about the environment. Thus, a hazy color has not only certain spectral and intensity values; it is also a cue or clue to distance and *qua* clue it is related to the organism's hypotheses about distance. . . . In any given situation, the organism is not indifferently ready for the occurrence of any or all types of objects, or sequences of objects. Rather, the organism expects, is *eingestellt,* for a limited range of events (32, pp. 249, 251).

In spite of the reasonableness of this position it may be only partially correct. It seems clear that in order to relate perceptual expectancy before the perceptual stimulus' occurrence to perception itself we must obtain independent measures of both perceptual expectancy and perceptual reports, and determine the degree of correlation which exists between the two. In most studies on expectancy and perception, expectancy is *assumed* and it is impossible to test the correlation of the two. We must also seek out and identify the conditions which lead to a negative correlation, a zero correlation, or to a positive correlation between the two.

Although Bruner and Postman (5) have shown that assumed expectancy about the color of playing cards does inhibit perception when the expectancy is incongruous with the perceptual stimulus (a negative correlation), it may not be possible to make a sweeping generalization that this will always be the case. The difficulty with such experiments is that the expectancy is assumed rather than experimentally induced, and there are no independent measures of expectancy and perception.

Solley and Long (39) have demonstrated the need for caution. In their study a paradigm similar to the one used by Schafer and Murphy (35), Rock and Fleck (34), and Jackson (19) was employed. This study was carried out to explore further the observation of Rock and Fleck that "autistic" subjects—*i.e.*, subjects who reported more rewarded profiles than punished profiles as figure in an ambiguous figure-ground test drawing—were only reacting to their expectancies. The one subject who showed considerable "autism" in the Rock and Fleck study was also the only

one who reported "setting" himself to see the rewarded profile and reporting that profile as the one perceived. In the Solley and Long study a training phase of 20 trials was given followed by 20 test trials. In the training phase two different procedures were used. In one, the subject was shown one profile for ⅓ second. It was named, and the subject was told he had won two nickels. When the other face was shown, he was told that he had lost two nickels. In another experiment one face was punished by loss of two nickels each time it was presented and the alternative face had "nothing" happen following it. It was anticipated that the subjects would come to overexpect the rewarded profile in the first experiment and the "neutral" profile in the second experiment. In the test phase each subject guessed which profile was going to be shown next—this was the measure of perceptual expectancy. After each presentation of the ambiguous test figure, the subject reported which face he perceived—the perceptual report. Two-by-two contingency tables were set up for the 20 guesses and 20 reports for each subject. Out of 54 subjects, only one showed a positive correlation between his expectancies and his perceptual reports significant at the .05 level of confidence. Three subjects reached the .10 level of confidence, two in the positive direction and one in the negative direction. Fifty of the 54 subjects showed no correlation even at the .10 level of confidence. The subjects did overguess the rewarded profile (and the "neutral" profile), but they just did not report seeing what they had expected. In fact, in the punishment-neutral condition the punished profile was reported significantly more often, but with no correlation with the verbalized expectancies.

This study *suggests* that a perceptual expectancy must be strongly overlearned before it overrides the effects of the immediate physical stimulus conditions. Wallin (43) was able to produce expectancies to see reversible figures in nonpreferred directions which overrode normal preferences, but he was able to do so only by weeks and weeks of steady training. How strong an expectancy must be before it takes precedence over immediate stimulus factors in controlling perception is an experimental question which remains unanswered.

We also know very little about how expectancies which are

highly motivated influence perception. Cantril theorizes: "Expectancy is the psychological co-product of emerging purpose when related to potential action in carrying out that purpose in concreteness. It is within a context of expectancies that we perceive, judge, feel, act, and have our being. . . . Action, purpose, and expectancy are, then, intimately tied to each other as factors involved in any perception" (10, p. 145). This suggests that expectancies which are intense and natural are purposive. An attempt to study such naturally motivated expectancy was made in a pilot study by Solley and Haigh (37).

In their study children's expectancies of Santa Claus and his gifts were related to their perception of Santa Claus. Reasoning that children's expectancies of Santa Claus increase in intensity as Christmas approaches, these investigators had children between four and eight years of age inclusive draw pictures of Santa Claus periodically during the month before Christmas and for two weeks afterward.

Figure 11 shows the drawings of three children as examples of the results. As Christmas approached (and presumably expectancies increased in strength), the children drew Santa as bigger, as nearer (in space), and as having a more elaborate costume and a fatter bag of toys. After Christmas the drawings became smaller and the bag of toys shrunk to nothing. Much more work needs to be done along these lines in which intense, natural expectancies are studied, but this pilot study does indicate an intimate relationship between intensity of expectancies and perceptual structuring.

Indeed, Postman and Crutchfield (33) present data which suggest that the specific effects of set are determined by their dynamic interaction with needs and stimulus structuredness. In their study a complex design was used. The subjects' task was to construct meaningful English words by filling in the blanks of skeleton words. For example, the skeleton word might be P-O – –, which could be filled out as P-O-R-K, P-O-N-D, P-O-L-L, or P-O-S-T. One of the solutions was always a food-related word. Three major variables were manipulated. Three sets of stimulus words varying in probability of food responses were used—comprising low, medium, and high probability lists.

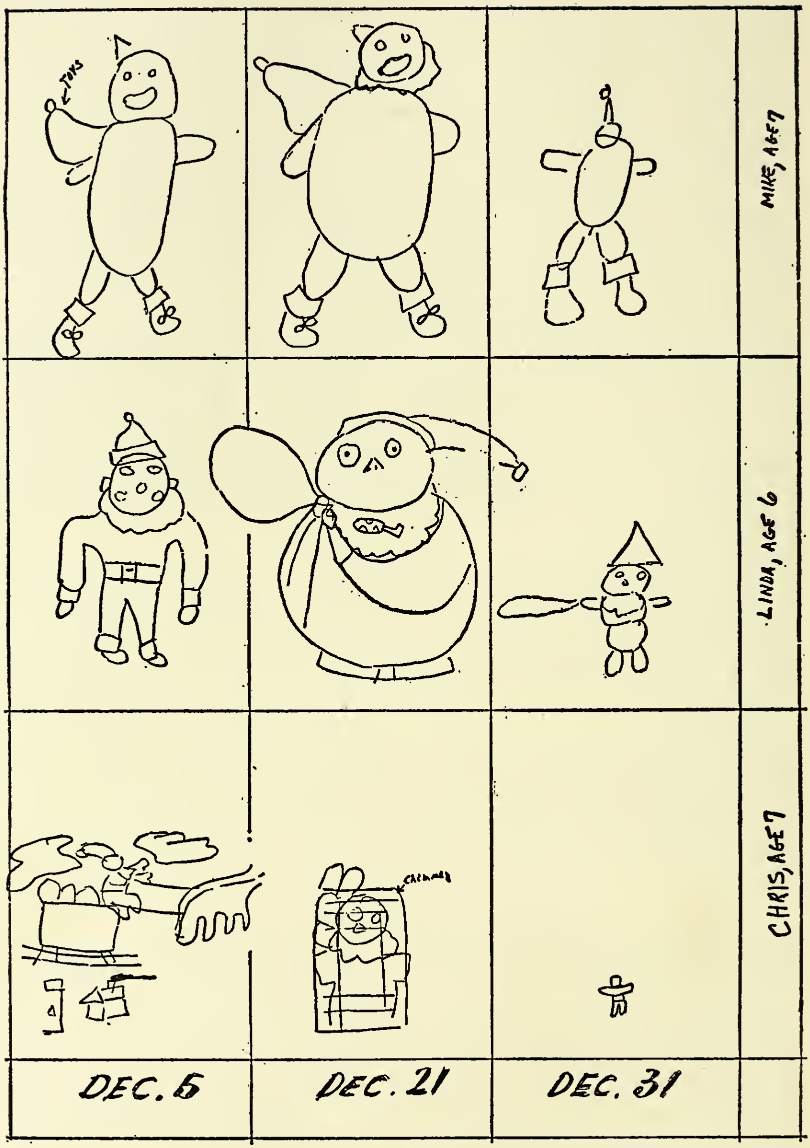


FIGURE 11. *Changes in three children's drawings of Santa Claus before and after Christmas.*

Five degrees of "set" were used with the subject giving 0, 1, 2, 3, or 5 food responses (a kind of warmup task) before the study began. Three levels of hunger, either 0-1, 2-3, or 4-6 hours of food deprivations, were studied. The results revealed that the number of food responses (*a*) increased with increasing probability lists (a validation of original standardization), (*b*) increased with increased set, and (*c*) did not change with food deprivation. However, set had more influence upon the low probability list than it did upon the high probability list; set and hours of deprivation interacted with set influencing the very hungry group more than it did the slightly hungry group; hours of food deprivation influenced the low probability lists more than it did the high probability lists; and all three major variables interacted significantly. Postman and Crutchfield conclude: "Intensity of need is one of the variables which modifies the operation of such general principles of cognition as selective 'sets' within limits defined by the characteristics of the stimulus materials" (33, p. 217). The Postman and Crutchfield study shows us that instructional sets produce more effect on perception when motivational sets are weak and are less effective when motivational sets are strong. Apparently there is an upper limit as to how much total effect can be produced by sets and the effects by two sets are additive below that limit. More experiments of this kind are needed in which the interaction of set, need, and ambiguity of stimuli is carefully spelled out. The effect of one of these variables seems to be curiously dependent upon the presence or absence of the others.

THE GENERAL EFFECTS OF *Aufgabe*, *Einstellung*, AND SET

Perceptual expectancy can be examined at many levels of complexity. Thus far we have been discussing highly specific expectancies; yet there are many more molar levels of expectancy. An individual adopts or is given a very general task-set, or *Aufgabe*, for a total experiment; or in everyday life events such as driving to work or reading a newspaper an individual sets himself toward a task as a whole and it is difficult to analyze precise segments

within that task as independent units of activity. The individual often develops a conscious task-attitude, or *Einstellung*, toward his task which governs his selective mental trend or "determining tendency." These are highly complex and largely unanalyzed (from a behavioral point of view). Yet there is little doubt that these molar aspects of expectancy influence the selection of what is perceived. The scholarly review of these factors by Gibson (13) leaves little doubt of this, and Floyd Allport's (1) summary of the operation of set provides many hints as to how these factors control the selective function of perceiving. Although we are indebted to Gibson and Allport, we shall not attempt to "'play back" what they have already written. Our orientation, here, is quite different; our purpose, our *Aufgabe*, is to examine and to relate perceptual expectancy, at several levels of complexity, to perceptual learning.

Although *task-set* and *task-attitude* are usually presented as cognitive factors, one can equally well analyze them in terms of their similarities to motivation. An attitude is rarely without a strong motivational component. We can scarcely see or hear without taking on a seeing or listening attitude, *i.e.*, without being motivated in a given direction. Bartlett writes: "Under no circumstances whatever does hearing without listening provide a basis for recognition. Listening, like hearing, is selective. . . . Selective listening is determined mainly by the qualitative differences of stimuli in relation to predispositions—cognitive, affective, and motor—of the listener" (3, p. 190). Also, task sets naturally arise in experiments by the establishment of motives and as motives change so do task-sets *unless* the subject is motivated to comply with the wishes of the experimenter.

Once a subject is motivated to comply with the instructions of an experimenter he is directed toward a specified end, and perceptually *excludes* events which are not congruent with his state of motivation. A classical study on task-set by Külpe and Bryan (25) can illustrate the effects. Three-letter nonsense syllables were exposed tachistoscopically. The letters varied in color and in spatial patterning. Instructions were given to report either (*a*) the letters themselves, (*b*) the colors, or (*c*) the spatial arrangement. It was found that subjects could not reliably report

the aspects for which they were not instructed. In traditional perceptual experiments it was the custom to use one's *friends or colleagues as subjects.* As such, the subjects were highly motivated to comply with their friend's (the experimenter's) instructions.

Besides the motivation-like properties of task-set, there are genuine cognitive properties. Task-sets determine the *assumption* that an individual will make about perceptual stimuli in a given experiment. Assumptions themselves probably develop prior to an experimental task, and the task-set selects which assumptions an individual will make. As Ittelson puts it: "The assumptive world of any particular individual at any particular time determines his perceptions, that is, provides him with predictions of probable significances. His assumptive world is, therefore, in a very real sense, the only world which he knows" (18, p. 290).

These assumptions often extend beyond the task at hand. Siipola's (36) study of sets produced by instructions illustrates this. Sets were given to one group to expect words dealing with boats, and sets for animals to a second group of subjects. If a subject was set for boats he would perceive "sael," presented tachistoscopically, as "sail"; if set for animals, as "seal." The same subjects served in a subsequent separate task in which skeleton words, such as — O-A-T, were filled out to make English words. The set induced by the *Aufgabe* of the first study carried over to the new task. The subjects could not verbalize what was happening, nor did they seem to have voluntary control over the set. This persistence of a generalized *Aufgabe* carries over to new situations without the individual being aware of what is happening; the individual only "knows" what he is perceiving at the moment, not its cause.

In summary, task-sets and task-attitudes direct perceptual acts, as does motivation. By so doing they determine not only what will be perceived at a given moment but also which perceptual acts will be learned. This is particularly obvious if we think of everyday life instead of laboratories as the context of perceptual learning. Daily needs and their satisfactions are the omnipresent task-sets which direct the selection of perception, not instructions provided by a researcher.

SCHEMATA

The term *schemata* has been used before in this book, yet we have not stressed it enough nor have we defined it. The term itself has been extensively employed by British writers (*e.g.*, 3, 16, 31, 41) but it is often ignored by American writers (for an exception, see 28). Schemata, as a concept, had its beginning with Head (16); was developed by Bartlett (3); and has been expanded by Oldfield and Zangwill (31) and Vernon (41).

Bartlett comments:

> It is fitting to speak of every human cognitive reaction—perceiving, imagining, remembering, thinking, and reasoning—as an *effort after meaning* . . . in certain cases of great structural simplicity, or of structural regularity, or of extreme familiarity, the immediate data are at once fitted to, or matched with, a perceptual pattern which appears to be preexistent so far as the particular perceptual act is concerned. This pre-formed setting, scheme, or pattern is utilized in a completely unreflecting, unanalytical and unwitting manner. Because it is utilized the immediate perceptual data have meaning, can be dealt with, and are assimilated (3, pp. 44–45).

For Bartlett, a *schema* is more than a task-set or a simple expectancy—yet it functions similarly. In a sense, a schema is a sort of skeletonized outline of prior experiences or of memories into which immediate perceptions are fitted, a concept not too much unlike Koffka's (24, esp. pp. 259–614) notion that perceptual traces articulate with memory traces to form percepts.

One should not gather that schemata are static. According to Gordon Allport:

> Infant and rodent have immediate goals and indulge in anticipatory goal reactions but have no *directive schemata*. . . . Men often have values without having any specific goal in mind. They may have a consistent direction of striving, but their goals are either transient or else undefinable. All of a rat's, but only a small bit of human, behavior can be characterized in terms of concrete goals whose attainment will

> de-tension specific drives. For the most part, *the course of man's behavior runs according to certain schemata, or in prolonged channels.* Only now and then are these channels marked by lights or buoys that represent specific goals. We may know a person's expectancies and even his past rewards, and yet be singularly unable to predict or control his future behavior, unless at the same time we know also his basic intentions, which are by no means a stencilled copy of his previous expectancies and rewards (2, p. 184). [ITALICS OURS.]

Schemata are directive. In this respect, Sir Henry Head's concept of schemata resembles that of Kant (see 31 for a discussion of this). Both have intentional attributes, a directedness toward articulating sense impressions and rendering perception possible.

Schemata are largely motoric, rarely in awareness. Although some schemata are cognitive and derive from the development of sensory frames of reference, many schemata are motoric and reflect complex sequencing of actions. Lashley used this concept to account for the tremendous speed and accuracy of such a task as playing a piano; the speed is far too great to allow proprioceptive feedback or conscious effort to control the sequencing of finger movements. Oldfield and Zangwill quote Bartlett on this point:

> First, the organism responds only to immediately presented external stimuli. But there is no observable case in which the conditioning of the response can be stated in terms of a narrowly isolable stimulus. *The response depends upon an arrangement of preceding responses which have already been organized.* The name given to these organized responses, which may produce their effects in the entire absence of any awareness of them on the part of the reagent, is *schema.* At any level of physiological response a number of these schemata must be assumed to be in operation (31, pp. 60–61).

The studies of Freeman (12) on physiological sets reflect, by and large, Head's and Bartlett's ideas. Motor sets prepare the observer; that is, they form a schematic frame of reference into

which incoming sense data will be organized. As the sensory samples are memorically accumulated, cognitive frames of reference or schemata are developed and new sensory data are "matched" with the stored samples. In all of this there is an active interplay of cognitive and motor factors, an energetic articulation of what-is-known with what-is-to-be-done. Without schemata perception would be aphasic—sensory materials would be "sensed" but without meaning, and perceptual learning would be almost impossible.

SUMMARY

The perceptual act begins with the individual expecting some perceptual stimulus. Studies have shown that this expectation reflects the probability of the stimulus event's occurrence, although strong incentives and motives also alter expectations. That is, individuals expect, look forward to, stimuli which have value or which have been rewarded in the past. These expectations are like "hypotheses" that such and so will occur. In this sense, expectations prepare the individual for receiving perceptual stimuli, perhaps producing activities which will increase the probability of occurrence of the expected stimulus. It was pointed out, also, that expectations rarely occur in isolation, but usually are integrated cognitive schemata into which perceptual materials can be fed.

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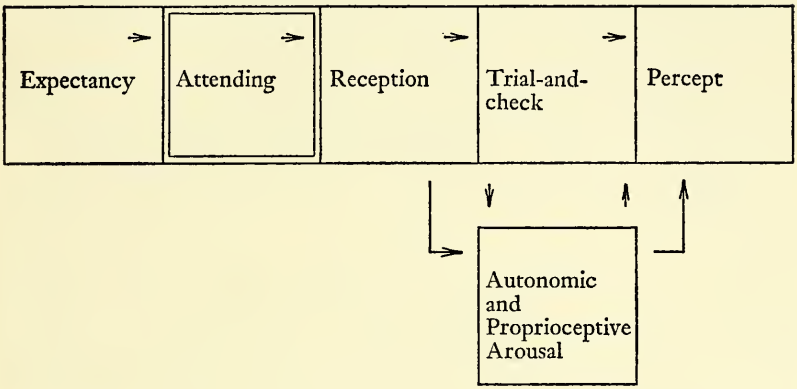

In everyday life we are often accused of "not paying attention" to what someone else is saying, or of "paying so much attention" to something that all else is overlooked. Teachers tell us they have difficulty in "getting Junior's attention" or that "Junior can't hold his attention on anything very long." If we are concentrating our attention upon something we are reading, then our wives can literally shout at us without our hearing them. These are only a few of the vast number of possible examples of "attention" at work in everyday life; yet psychology has had a long history of efforts to *ignore* attention and its implications both for learning and for perception.

AN ANALYSIS OF "ATTENTION"

In 1890 James made the criticism that

> So patent a fact as the perpetual presence of selective attention has received hardly any notice from psychologists of the English empiricist school. . . . The motive of this ignoring of the phenomena of attention is obvious enough. These writers are bent on showing how the higher faculties of the mind are pure products of "experience"; and experience is supposed to be something simply *given*. Attention, implying a degree of reactive spontaneity would seem to break through the circle of pure receptivity which constitutes "experience," and hence must not be spoken of under penalty of interfering with the smoothness of the tale. (19, p. 402).

In spite of James' criticism and Titchener's (33) declaration that attention was a basic feature of psychological processes and in spite of a number of articles (e.g., 1, 4) and books on attention (*e.g.*, 24, 27, 33), in 1941 Paschal had to repeat the same sad fact.

> Modern psychologists . . . have ignored it (attention), or have merely paused to pay their respects (or disrespects) in passing. The ebb of the influence of attention can be seen in the fact that in the past two decades many textbooks have omitted all reference to it. The biennial reviews of its literature in the *Psychological Bulletin* ceased ten years ago. But despite the criticisms that have been aimed at it, the attempts to read it out of the party, attention has had a hardiness that has enabled it to survive (21, p. 383).

Although Paschal also noted a renewed interest in attention, by 1949 Hebb (13) had to rebuff his contemporary fellow psychologists for ignoring the phenomena of attention and again in 1951 Berlyne restated the point: "Attention is one of those topics that loomed large in the psychological systems of some thirty or more years ago and has been rather neglected of late, but since its importance, for the study of human behavior, especially in applied psychology and psychopathology, cannot be ignored,

behavior theory must come to grips with it sooner or later" (3, p. 137).

In short, the problem of attention is a pesky creature that keeps circling us like a Socratic gadfly. As a consequence we are moved to make a theoretical analysis of the problem. As sketched in Chapter 2, the *preparatory* phase of the perceptual act consists of two components—expectancy and attending. Indeed, it is a cardinal thesis of ours that it is virtually impossible to perceive without attending. This is, of course, an old idea. Wundt wrote: "The state which accompanies the clear grasp of any psychical content and is characterized by a special feeling, we call *attention.* The process through which any such content is brought to clear comprehension we call *apperception.** In contrast with this, perception which is not accompanied by a state of attention, we designate *apprehension*" (36, p. 209). We can apprehend or register stimulation but we cannot perceive without attention. Mere reception of a stimulus is insufficient for perception, as detailed by James who wrote: "Millions of items of the outward order are present to my senses which never properly enter into my experience. Why? Because they have no *interest* for me. *My experience is what I agree to attend to.* Only those items which I *notice* shape my mind—without selective interest, experience is an utter chaos" (19, p. 402).

We could trace out the historical roots of various conceptions of attention, but this approach to the problem at hand would carry us beyond our objectives; indeed, a historical analysis would repeat our sources of indebtedness (1, 4, 19, 24, 27, 32, 33, 36). Rather than make a historical analysis we shall proceed to develop our own position, making articulations with historical precedents from time to time.

In Chapter 8 we noted that our expectations, especially when motivated or intentional, direct us in our searching for stimulation; and by so doing, they increase the probability of our encountering specific sources of stimulation. Individuals invest energy (25, 32) in this seeking, searching activity. Tentatively,

* The terms "perception" and "apperception," as used by Wundt, do not correspond with modern usage. In modern terms, they would be translated as "bare sensory impression" and "perception" respectively.

we may define attention as the acts of the individual which govern the probability of maximally receiving specific sources of stimulation. As we shall show, this definition is not sufficient in and of itself. The attentional act is much more complex, embracing the *moment before and during* reception of a potential perceptual stimulus.

As an act, attention is (*a*) selective, (*b*) integrative, and (*c*) energic. Each of these aspects of the attentional act serves the purpose of controlling stimulation, either by producing new stimulation, by focusing upon stimulus sources to maximize stimulation from the sources, or by amplifying whatever stimulation is present and active. We shall proceed by analyzing each of these aspects separately, although we fully recognize that all three aspects are part and parcel of every act of attention.

Attention as a Selective Mechanism

Nearly all theories of attention have stressed the selective aspect of attention, particularly when involving voluntary attention (see 19). Pillsbury (24) wrote that attention "means largely that some one element of consciousnesss is picked out from the others, and given advantage over them" (p. 1). ". . . Increase in the degree to which an impression is conscious and increase in attention to that impression are synonymous terms" (p. 10). Here we see the selectivity of attention in admitting sensory impressions into consciousness.

As Sherrington (28) pointed out, the evolutionary process provides not only for independent action patterns but also for a "right-of-way" if one action pattern is grossly incompatible with (cannot be carried out at the same time as) another. It will readily be noted that some sort of *selection* among the various possible responses must be provided by the innate system itself. The organism must "select"; or to speak more precisely, some sort of competition among the various perceptual tendencies must be resolved by a priority system within the living structure itself.

At any given moment in time an individual is immersed in a sea of stimuli; he is incessantly receiving stimulation, each new source of stimulation, each new input struggling for dominance.

Yet the individual can carry out only a limited number of structuring actions at a time. Some forms of stimulation receive priority, normally over others; there is survival value in structuring strong and intense stimulation. A landslide of stones can be avoided if their thunderous sound receives a high priority of attention; a lion's roar can signal his advance; a sudden pain from fire can effectively serve as a signal for withdrawal of one's hand. These are all instances where certain stimuli are high in the hierarchy of attention value; as Stagner and Karwoski say: "Those who were not selectively attentive to loud sounds, movements, etc., probably were liquidated" (31, p. 200).

This means in effect what Razran (26), among others, has called "dominance." The principle of dominance is not simply the easy and circular principle that whatever is weaker fails, and whatever is stronger wins. Such a circularity would serve no purpose. The principle of dominance states that when competing or conflicting attention tendencies are aroused, the rule is not compromise but full-fledged victory of one, and defeat of the other. We should expect, if the dominance principle holds for our dynamics of selection, that there would be no true "suspended attention." Attention would hop from one thing to another, never fall between two stools, unable to find an object. Experimental studies of the "shifting of attention" (see 35), as in noting the appearance and disappearance of a sound, or better yet the movements involved in scanning as in the case of reading, indicate the presence of this process of biological selection or dominance. One cannot hold the fixation point indefinitely without seeing different aspects of it, that is, alerting oneself from moment to moment to attributes previously ignored. The process of reading is not a fusion or jumbling of letters, but a transition from one integrated response to another by the sharp transition of the saccadic movement. At a higher level, chains of free association typically leap from one component to another. They do not slide or ripple forward like streams of water. As William Stern said: "Attentional comprehension is at once a state having some particular vividness and a *moving forward* to a new and higher awareness" (32, p. 474).

We have tried to set the stage for a conception of attending,

as a biological response, of a higher order involving transition from one response to another. We have not, as yet, found it necessary to introduce any conception of attention as a "state" of consciousness as did Titchener (33) and Wundt (36). We have thought of attending as an act involving selection among competing components, the establishment of dominance relations, and the transition (as dominance relations change) to new components.

Most of the acts of selecting which, in this presentation, we have related to the process of attending involve adjustments of the sense organs and frequently adjustments of head, neck, arms, and hands, indeed of the whole body; not chaos but integrated or interrelated action of many components is evident (20). Often expressive behavior, especially as given in words, denotes the object to which the act of attending is directed (1). Under ordinary conditions we would not hesitate to say that our subject tells us what he is attending to. For purposes of the present exposition, it is not necessary to formulate a theory of the nature of consciousness. It is, however, necessary to accept the fact that in our subject's universe of discourse there is a definite meaning attached to the statement that he attends to something and does not attend to something else. Under ordinary conditions of social living we are not hesitant to accept his testimony, other things being equal, as corresponding to a genuine selection process going on in him with reference to his environment. We are not disturbed regarding the metaphysical issues of the mind-body relationship, but will content ourselves with the statement that there is a good parallelism in general betweeen the world of selection as known biologically, and the world of selection as described by the subject, usually in the language of awareness. He reports, for example, in the case of supraliminal material that he sees a circle, triangle, or square, and other times that he does not see it. Assuming that communication has not utterly broken down, we believe that the seeing and not seeing the circle corresponds to awareness and nonawareness of the presented circle, and that this in turn corresponds closely to processes of selection carried out by the subject with reference to environmental materials presented. We shall, for convenience, stick to the more

objective way of describing the process of selection. In other words, we shall stick to the biological definition of acts of attending, and shall not hesitate to use the verbal formulations of the subject as indicating the character of the environmental objects to which his major response is being made. He is not describing the act of attending; he is describing the things attended to. He is, in other words, giving us semantic indications of his gross behavioral adjustment, his selection or nonselection of certain materials within the gamut of stimulating materials in his environment.

By now it should be clear that acts of attending are selective in two quite different ways. In the Titchenerian framework the individual was considered more or less "fixed" and the environment changed, whereas in the Jamesian frame of reference the environment was considered more or less "fixed" and the individual was active. In both of these situations selection occurs but by different mechanisms of attending. In the latter situation the individual is actively searching, scanning, seeking for specific forms of stimulation, being guided by his expectations and energetically directed by his motives. The individual locomotes about, adjusts his sense receptors, and focuses his activities in search of specialized stimulation. Metaphorically, he is a perceiver in search of a percept. In general these perceptual stimuli are either primarily or secondarily reinforcing. When his search activities produce a momentary reception of the sought-for stimulus, he is rewarded and his search stops, at least momentarily.

In the "fixed individual-changing environment" situation, selection also occurs although by different mechanisms. Every stimulus which has stimulation value can potentially be attended to or selected out of a field of stimuli. This does not mean that at any given moment all stimuli have *equal* possibilities of being selected. Stimulation which is being attended to at any given moment, for whatever reason, automatically blocks attention to other temporally contiguous stimulation (3). This is the old law of "prior entry into consciousness." This inhibitory effect has been noted by nearly all psychologists who have theorized about attention. In our framework we conceptualize this mechanism in the following way.

Consider all the perceptual acts that an individual can carry out in structuring stimulation. We might list these as PA_1, PA_2, . . . PA_n, or "Perceptual Act_1," "Perceptual Act_2," . . . , etc. These perceptual acts can be ordered as to their "oppositeness," just as moving your hand up is "opposite" or mutually antagonistic to moving your hand down. If one of these perceptual acts is momentarily active, for whatever reason, it will automatically "oppose" or "inhibit" all the other perceptual acts, but some more than others depending upon their respective degrees of incompatibility. It would take some strong, intruding force to overcome the momentary hierarchy of perceptual acts. For example, a strong stimulus—*e.g.*, loud gong or strong shock—which occurs while one is actively attending to another source of stimulation would produce such a strong "perceptual act to strong new stimulus"—*e.g.*, structuring the shock as painful—that the perceptual act hierarchy could be altered. Attention is selective in the "fixed individual-changing environment" situation primarily because the individual cannot carry out simultaneously all possible perceptual acts; just as it is impossible for one of us to dance a jig, waltz, read a book, tell time, flyfish, and pluck a banjo simultaneously.

Attention as an Integrative Mechanism

Although it is impossible for us to do *some* things at the same time, this is not true for all things. We have seen one-man bands. Studies of the "span of attention" (24, 34) tell us that it is possible to attend to several things at once, especially when these things form a pattern. It is within this frame of reference that we wish to use the concept of focusing. When our subject is confronting a complex stimulus with many components that are interrelated with one another in various ways—as would be true of the viewing of words, printed pages, pictures, or social situations—it is not sufficient to say that he attends, let us say, to the letter *A* and that he is inattentive to everything else. There are manifest levels of selection or awareness which correspond to Sherrington's integrative system of levels. He is, for example, attending to the face of the experimenter and making a much

less highly coordinated response to the remainder of the experimenter's body and to the table and room. The Titchenerian School (33, 34) attempted for some years to determine how many levels of awareness could be defined at a given time. We shall content ourselves with the observation that one may pass from a whole to detail, as from a whole picture to the center of interest of the picture, and one may pass to a finer detail such as a bit of shading introduced under the eyes of a character represented in the scene. The point we wish to stress here is that passing from one detail to another no longer exemplifies the complete exclusion of some details in order to give full inclusion to others. Rather, there is peripheral attention to detail as one gives one's attention to a whole, or peripheral attention to a whole as one gives full attention to a detail. Whatever we may think of this theoretically, there are manifestly reportable degrees of awareness, alertness, or selection, and to these we shall apply the broad concept of focusing. Focusing is the process of ordering with respect to the range of attending.

We have in mind here an analogy with a camera lens. It may be a wide-focusing lens which takes in breadth while losing detail or which can be readjusted to focus sharply upon a more limited part of the world, picking up clear details but losing breadth of sweep. From this point of view, we have regarded integration at the level of psychology or functional unification as a kind of biological integration. In the Sherrington scheme there are many forms and types of integration, and so there are, psychologically, in the process of attending. It is necessary, however, to insist that integration expresses itself psychologically in a pattern of selectivity in which emphasis is given to some components and less emphasis to others. The integration is not a democracy of equals; it is an ordered hierarchical system involving some instability from time to time, but some permanence in the ground rules by which there must always be maintained some sort of headship or leadership. As one drives one's car while talking to a friend, the headship in the integration of attention can be given to what our friend is saying to us. But let us encounter serious danger signs which offer peril to life and limb and the

ground rules of the integrated system, built up within us, give dominance advantages to the perceptual and motor activities involved in driving.

There is still another way in which the act of attending is integrative. The searching, scanning, and shifting involved in active attention bring on fresh samples of stimulation; first from that source, then another, and still another as the receptors rove over the environment (31). As our senses adapt to a source of stimulation we seek another (4, 31). These successive acts of attending bring stimulations into close contiguity with one another, an important requirement for sensory integration or *S-S* learning as we presented it in Chapter 5. By so doing, the perceived environment becomes integrated into a meaningful whole; Gestalts become supraordinated into larger Gestalts, and the momentary fragments of experience become integrated into a world of experience.

Attention as an Energizer

Attention has sometimes (3, 19, 25, 27, 32) been conceptualized as supplying the additional energy necessary for bringing a percept or memory or idea into awareness; an idea fundamental in psychoanalysis (see footnote p. 186). We agree that the act of attending does bring into play or reflects the additional energization necessary for making a percept (or memory or idea) more discriminable from other percepts (or memories or ideas). Thus, Stern spoke of "the dynamic factor of tension in searching, expecting, productive attention" (32, p. 474). And Berlyne wrote that "If attention ($_s\dot{\bar{E}}_{\bar{R}}$) to a given stimulus is high, the perceptual response ($\bar{r}$) will have a high vividness (amplitude, A) and therefore, presumably, the perceptual response-produced stimulus ($\bar{s}$) will have a high intensity" (3, p. 142). Berlyne, of course, is treating attention as an effective excitatory potential ($_s\dot{\bar{E}}_R$) to a stimulus; as such attention for him is a state of energization to respond perceptually rather than an energy producing act. Ribot also writes:

> Attention certainly *causes an intense innervation* . . . the brain plays a complex role. In the first place, it inaugurates the movements that accompany perceptions, images, or ideas; afterwards, these movements, which frequently are intense, return to the brain by way of the muscular sense as sensations of movement; the latter *increase the quantity of available energy*, which on the one hand serves to maintain or to reinforce consciousness, and on the other, returns to its original starting-point in the form of a fresh movement (27, pp. 20–21. [ITALICS OURS.]

Even more recently Rapaport (25) has developed an energic concept of attention, treating attention as the deployment or investment of mobile energy into tentative drive-representations (percepts, ideas, memories) bringing them into consciousness.*

We have deliberately used the term "act of attention," as did James (19) and Stern (32). As an act, attention can carry out its functions without regard for the specific sources of energization. At times the energy needed for attention may come from the environment; at times, it may be produced by the search movements themselves (27); at times, the energy may come from internal drive states (3); and at times, the supply may come from surplus or generalized energy such as Rapaport (25) and Hebb (13) theorize about. From our point of view the sources of energy are not nearly so important as the fact that additional energy is being fed into the process of structuring percepts.

Stern describes vividly how this additional energization functions:

> In the act of attention energy immediately available for the performance at hand is summoned and utilized at once. Or to put it more briefly, in the act of attention the individual becomes "concentrated" upon the performance.
>
> The state of having energy immediately available is called "tension," and this tension, which is always involved in atten-

* Freud initiated these ideas, in Chapter 7 of *The Interpretation of Dreams*, which Rapaport later developed. These are fundamental ideas in psychoanalytic theory and their adequate treatment would call for a whole volume.

> tion, is *psychophysically neutral.** Not only experience, but also those parts of the body which are related to the performance are tense with respect to what is about to occur. Both may interfuse completely with each other. . . .
>
> The dynamic structure of attention must be completed by the ever present counterpart of concentration: dynamic inhibition of the other areas of personal activity.
>
> Since the person's supply of energy is limited at all times, concentration upon one area is obtained at the cost of withdrawing energy from others. The sharper the focus directed upon the specified performance, the duller the background into which all the rest of personal existence is thrown (32, pp. 475–476).

Until recently we had little or no idea how the process Stern describes could come about. However, several physiological studies (14, 15, 18) have cast light on the energy-deployment aspect of attention. In the studies by Hubel, Henson, Rupert, and Galambos (18) and by Hernández-Péon, Scherrer, and Jouvet (15) attention to auditory stimulation was studied; whereas Hernández-Péon, Guzman-Flores, Alcaraz, and Fernández-Guardiola (14) studied visual attentional processes.

Hubel, Henson, Rupert, and Galambos (18) have discovered cells in the auditory cortex of the cat which can be activated by auditory signals *only* when the animal "attends," *i.e.*, orients his body, toward the source of auditory stimulation. Unless these cells are energized by attention they fail to respond. The study by Hernández-Péon, Scherrer, and Jouvet (15) has located even more basic mechanisms at a subcortical level. Electrodes were implanted in the brain stem of cats, in the auditory pathway. The auditory nerve did not transmit auditory stimulation when the animal was "attending" to two mice in a bottle placed before him. Attending to the visual stimulus (the mice) reduced or stopped

* This idea is strikingly similar to Rapaport's (25) concept of nonbound, mobile energy which is cathected to ideas or memories or percepts bringing them into consciousness. See Chapter 14 for a presentation of Freud's earlier version of the System-Consciousness.

energization of the auditory nerve. As Stern (32) pointed out, energy concentrated upon one object of attention withdraws energy from other objects.

The same point is made for visual transmission when auditory and olfactory stimuli are attended to. Hernández-Péon, Guzman-Flores, Alcaraz, and Fernández-Guardiola (14) observed that when a cat focuses its "attention" upon auditory or olfactory stimuli, photically induced potentials are abolished or reduced. These authors observed that deactivation or blocking of the visual pathways occurred at nearly all levels and concluded that the blocking took place in the retina, a conclusion that seems unlikely but may prove to be correct. In any case, if the animal deploys his available free energy in attending to a given stimulus, there is less or no energization of other physiological mechanisms responsible for other forms of stimulation.

THE CONDITIONING OF ATTENTION

Implicit in the foregoing is a distinction between classes of response. We are stressing the biological importance of behavior which adjusts receptors for better reception, which puts the individual in a better position to see, to hear, to smell, to feel, and so on. With Guthrie (12), we find a necessity to separate such behaviors from other types of motor behavior. And we further agree with Guthrie that these behaviors, which overtly express the act of attending, are conditionable just as are other acts. The act of attending (or not attending) is capable of being conditioned as are action units.

During physical and psychological development the individual learns to attend or, in E. B. Holt's (16, 17) terms, to respond maximally to a large but finite number of things. As one glances around the room he is in, he finds that he does not attend equally to all possible stimulus sources. In the words of a naïve observer, he sees chairs, tables, curtains, windows, lamps, etc., or generally stated he sees objects. From our point of view an object is a complex stimulus source to which an individual has *learned* to attend. Conversely, the things which "fill up" the space between objects

are merely "fillers" in that the individual either has extinguished his acts of attending to them or else has never learned to attend to them.

We believe that most acts of attending are conditioned along the lines of operant conditioning (30), although classical conditioning is conceivable. That is, if an individual makes receptor adjustments, or some search behavior, and is immediately given a reinforcement stimulus, then the probability of his repeating that attentive response will increase. The college professor who looks at a student while lecturing, and sees the student smile or nod as in approval will look again and again at that student.

Let us go a step further and examine the factors that control or direct attending, because attending rarely arises spontaneously. One of the major factors, at least in the early stages of development, is motivation. The stimulus cues triggered off by states of motivation elicit primitive search behavior, just as the infant struggles to see its mother when hungry. Among the earliest aspects of the environment that are attended to are those complex stimulus sources necessary for biological survival. Hunger, thirst, and elimination—need-produced cues—serve as discriminative stimuli for the activation of attentional responses, and those external cues which consistently occur with the attentional responses come to elicit attentional responses in their own right.

A man who loves to hunt will notice—that is, attend to—a small tuft of hair sticking out from a limb on a tree, whereas a person who doesn't care for hunting would scarcely know that a squirrel was behind the limb. And the difference between a "good" and a "bad" experimenter often lies in his relative ability to direct his attention to details or to encompass the entire scope of an experiment. Whether a stimulus event triggers off an act of attention or not has often meant the difference between life and death for a soldier on the battlefield. These are only a few of a vast number of examples of attentional acts which involve as their occasion some discriminative stimulus.

Attention may be considered in still another way. It is possible that individuals learn to deploy available energy in characteristic patterns. Thus, some people may come to invest their deployable

energy in one sense modality or another. One man may learn to be attentive, *i.e.*, deploy his energy to sounds, such as music, or speech, or bird songs; another may learn to invest energy in visual sources, such as art forms, or colors. As such learning takes place some of the free energy becomes bound or permanently cathected to specific sources of stimulation. In the parlance of learning theory, we would say that certain sources of stimulation have acquired secondary reinforcing or motivating properties. We attend more intensely to such stimuli because we have learned to invest energy in them.

It should be mentioned here that some of the studies in which we attempt to condition attention and its deployment may link our work to that of Piaget and his co-workers (22). In their extensive series of experiments on perceptual activity, these investigators have demonstrated progressive developmental changes in response to a broad array of visual stimulus conditions. They have interpreted these progressive changes as functions of the gradual emergence of more refined patternings of attention deployment. The infant, according to Piaget, tends to anchor attention on dominant objects in the field. Such centerings of attention are assumed to produce "centration effects" (automatic overestimations of stimuli in the center of the attentional field) that are an inherent feature of the functioning of the perceptual apparatus. As the child grows older, Piaget states, he learns to deploy attention in more complex ways that balance out these misperceptions of apparent size and hence improve the child's adaptive coordination to conditions in the external world (see also 2).

Gardner (6, 7); Gardner, Holzman, Klein, Linton, and Spence (8); and Gardner, Jackson, and Messick (9) provide evidence that adult humans may be consistently different in their strategies of attention deployment, conceived in the general framework Piaget has provided. Gardner and Long (10, 11) have provided evidence in support of the general "law of relative centrations" itself. The ways in which these strategies emerge, and the reasons for the gross individual differences observed, have not been fully spelled out. New studies may help to clarify the effects of various rewarding and punishing conditions on these and other aspects

of attention deployment and will, we hope, shed new light on the motivational factors guiding the developmental emergence of attention deployment as an adaptive tool.

SOME EXPERIMENTAL EVIDENCE

A fairly thorough search through psychological and general scientific journals revealed only one study (34) in which the conditioning of attention, as such, is reported. To provide a preliminary check on some of the theoretical ideas proposed in this chapter, one of us (C.M.S.) and Dr. John Santos in our laboratory devised some simple experiments which await further work before publication. We present them here to illustrate more clearly how our theoretical ideas can be used.

Nine- and ten-year-old children were studied. Two experimental tasks were given each child. In the first task a "conditioning panel" was presented, as shown diagramed in Figure 12. Four plastic animal figurines—a lion, a sheep, an elephant, and a camel—were placed in alcoves on the panel. Lights in the alcoves came on one at a time (randomly turned on by a tape-recorder-programmer system), and the child named the animal which was illuminated. The children were told that this was a game like "follow the light around." As the child shifted his focus to a newly lighted window and named the presented animal, he shifted his attention. One fourth of the children were told "uh-huh," "fine," "you're doing good," and so on about 80 per cent of the time when they shifted their attention to one of the figurines and not the others; four experimental groups were thus formed. One experimenter sat in front of the child and counted the number of times he looked at each figurine while the other experimenter sat behind the child and gave the reinforcement stimuli. The results of this task showed that the children would attend to the "rewarded" figurine between successive light presentations or would name a lighted figurine and then glance rapidly at the "rewarded" figurine. After a little training the children could not keep their eyes away from the rewarded figurine.

This task was followed by a transfer task involving search.

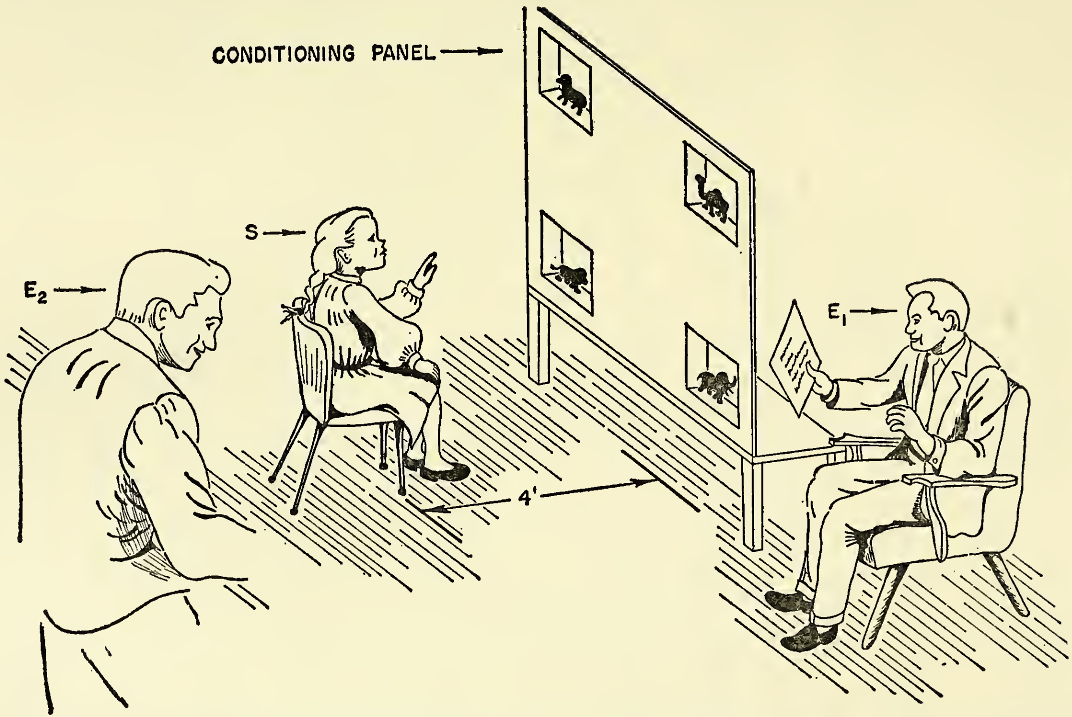

FIGURE 12. *Diagram of "conditioning of attention" experiment sho wing conditioning panel.*

Forty other plastic figurines of animals and people were scattered around on a pegboard panel—referred to as the search panel. (All figurines were dipped in white paint to remove color cues.) A child was shown one of the four figurines and was told to find it, to point to it as quickly as he could. He would search, locate, and point, and then would look away while one of the experimenters took the located figurine off the search panel and put on another at a different, randomly selected point. (A table of random numbers was used to locate spatial coordinates on the pegboard.) Each figure was searched for 16 times, four times in each quadrant of the search panel, and the time required for search was recorded. The results of this task showed that the figurine for which attentional shifts had been rewarded on the conditioning panel was located more rapidly than were figurines for which attentional shifts had not been rewarded.

These investigators recognize fully that there are many intricate points to be controlled in such experimentation, and do not present their study as a finished product. It serves only as an illustration of how our theory of attention and the conditioning of attention can be tested. It also illustrates the importance of attention in preparatory—searching—sampling acts which prepare the organism for the simplest kind of perceptual identification.

These results agree with those found by Walters (34). In his study, undergraduates of Kansas and Stanford Universities were observed; each subject going through a "card game" in which various colored cards with imprinted numbers were used. The subjects were told this was a problem-solving situation. As they called out their guesses, the experimenter told them they were right or wrong; however, he only told them they were right on cards with a specific color. In this part of his experiment, the color acquired secondary reinforcing properties. In the second part of his experiment the subjects were given a figure, as used in a Gottschaldt test, and were told to find this figure on an embedded-figures card. The figure they were searching for actually occurred several times, each time with a different color. The subjects located the figure colored the same as the cards which had been previously rewarded. Walters interprets this as meaning that their attention was drawn to the rewarded color. As in

the Solley and Santos study, subjects scan or search until they find a rewarding object (or color) and stop. They do not stop searching as quickly when they look at a nonrewarding figure. So far as we know, Walters was the first to say specifically that he conditioned attention, although the conditioning of attention assuredly has occurred in many other studies.

SOVIET STUDIES OF THE ORIENTING REFLEXES

Our book is conceived largely in terms of the experimental psychology of the Western World in the mid-twentieth century. Among the provincialisms of our Western psychological approach must be included neglect of Indian and other Far Eastern psychologies, and even the neglect of the Soviet psychology of recent decades. Though at least three American psychologists—G. H. S. Razran, Alexander Mintz, and Ivan D. London—have carried the responsibility of making Soviet psychology known to the Western World, there is still vast ignorance of which we ourselves plead as guilty as are most others. Without specialized knowledge of the history of these concepts and without knowledge of the Russian language, we have done what we could here and there to make use of the concepts of Pavlov and his intellectual descendants, but this is grossly insufficient, especially as regards their contributions to problems which the West subsumes under attention. As already noted, our neglect of two huge contributors to Western thought—Freud and Piaget—can be condoned only in terms of the massive scope of these contributions and the impossibility of doing justice to Freud and Piaget while trying to do justice to the sweep of Western clinical and experimental research as a whole. Our neglect of Soviet psychology, especially as it relates to the province of orienting and attending, is, however, much more flagrant and calls for a more explicit avowal.

Soviet psychology, springing in considerable measure from the physiological researches of Sechenov and Pavlov and influenced by others not of the Pavlovian school, began to make its mark on the Western psychologies in the first decade of this

century, became very important in the Watsonian behaviorism of the twenties, was profoundly assimilated by Hull and other American learning theorists, and has in recent years been the subject of a number of specialized reviews. The basic conception of Pavlovian or "classical" conditioning was that any stimulus S^1 presented jointly with or just before an original or unconditioned stimulus S will in time evoke the R, or response closely similar to the R, originally observed to follow the S when presented alone. This essentially quantitative problem, however, has moved in many directions, including studies of the relative intensities, durations, contexts, or embeddedness qualities of the S and the S^1 and likewise of the R, together with problems of resistance to extinction, spontaneous recovery, transfer and generalization, interference with other conditioned responses involving negative transfer, and the whole area of opposition between "excitation" and inhibition brought to bear upon the conditioned response. This is a vast quantitative psychology only scantily considered here.

But side by side with this major contribution is the study of the "orienting reflexes" noted almost as early as were the basic classical conditioning responses themselves, referred to by Pavlov as the "what is it?" response: the first response of the organism to the unexpected, the unfamiliar, the situation or stimulus to which no ready response is at hand. This seems to us to belong essentially in the category of problems of "set" or, better still, "readiness," to which we have already given some attention. The organism, when not "ready," carries out a series of orienting or primitively investigating responses, such as pricking up the ears, moving eyes or head in such a way as to guarantee, from a broad biological point of view, increasing exposure to that which is dominant in the stimulus field at the time—that which is new, sudden, of massive impact, or of sharp salience—as against the background qualities already present. Often the orienting reflexes involve specific, identifiable, physiological aspects, such as the dilation of the forehead blood vessels or the constriction of finger blood vessels. Sometimes, indeed, the earliest orienting reactions look like muted expressions of what Hunt and Landis

call the startle reflex. Ordinarily, however, the true conditioned response model can be brought to bear when once the orientation has been set going. The organism is prepared for something, and the something for which it is prepared becomes the conditioned stimulus. It is easy to see why, under certain conditions, there is rapid adaptation when there is no longer a need to ask "what is it?" and the organism "knows" what it is. The conditioned response may build up rapidly, and may go its way in terms of generalization, extinction, or what not, already studied through much experimental work. It may even be argued that the orienting reflex always precedes the true classical conditioning process. There are times likewise in which the smoothly flowing conditioned response is interrupted by a fresh orienting reflex. Orienting reflexes likewise become less frequent in well-defined and familiar situations, and as the child grows they may perhaps become less frequent, at least if the child remains in a relatively familiar environment. But we can perhaps do no better than to quote here a summary from the chapter by A. A. Smirnov, in the volume edited by Brian Simon entitled: *Psychology in the Soviet Union* (29).

> Soviet psychologists have made an extensive study of higher nervous activity; in particular, attention may be drawn to researches on the work of the analysers and the reflex nature of reception and its mechanisms. E. N. Sokolov has studied the reflexes involved in the regulation of sensitivity, above all the orienting reflex, as one that plays an essential role in the "tuning" of the analysers. Among the many components of this reflex, particular attention was given to the vascular and the related skin-galvanic responses and to changes in the electrical activity of the brain.* These investigations showed the characteristics of the orienting reaction both to indifferent and to conditioned stimuli. At the same time, and this is especially important, they threw light on the character of the reaction to verbal stimuli. They also indicated the exceptional

* Cf. Sokolov,"Higher Nervous Activity and the Problem of Perception," p. 92 (Ed.).

stability of the vascular reactions evoked by new direct stimuli acting with a verbal stimulus which creates a "set" * to these stimuli. S. V. Kravkov carried this work further in his study of interaction between analysers; that is, of conditioned-reflex connections formed not only in one analyser but also between different interacting analysers. Such research rests on Pavlov's view that higher nervous activity is a constituent part of a much broader problem, that of the reflex nature of sensation (29, pp. 30–31).

[Note also the orienting activities] of pre-school children in the formation of motor skills and abilities. They show the importance of preparatory orienting investigation in carrying out specific tasks, in forming and strengthening the skills involved and subsequently in changing them; above all, they show how speech gradually acquires an increasingly important role as the child develops, indicating the interrelation between speech and visual, motor, motor-tactile and other means of orientation at different levels of the preschool child's development. Further, they revealed the conditions and form in which language evokes an orienting reaction in the child.† (29, p. 38).

We also quote D. B. Elkonin, again from Brian Simon's book:

Secondly, there has been insufficient research into the orienting-investigatory reflex in young children. Pavlov attached exceptional importance to this unconditioned reflex.

Each minute, every new stimulus that strikes us evokes a corresponding movement on our part to find out more about this stimulus. We look at an appearing form, listen to a sound that arises, strain to inhale a smell, and, if there is a new object near us, we try to touch it; in general we endeavour to encompass or grasp every new phenomenon or object, using the corresponding receptor surface, the appropriate sense organ [48:308].

* *Napravlenmost,* literally "direction," "tendency," "set" (of a current) (Ed.).
† Cf. Zaporozhets, "The Development of Voluntary Movements," p. 108 (Ed.).

Figurin and Denisova, in their careful study of the first year of life, point out that the mechanism of the orienting-food reflex is ready from the moment of birth; the orienting reflex to labyrinthine stimuli is also inborn. The orienting reflex to sound and sight stimuli emerges somewhat later, the aural orienting reflex at the second week (the authors call it 'aural concentration') and the visual orienting reflex at between three and five weeks.

> It is scarcely rated highly enough—this reflex that one might call the investigatory reflex, or, as I call it, the 'What-is-it?' reflex; this is . . . one of the fundamental reflexes. Both we and the animals, at the slightest environmental variation, dispose the appropriate receptor apparatus in the direction of the agent of the variation. The biological significance of this reflex is enormous. If an animal lacked this reflex, then its life would every moment hang by a thread. And for us this reflex goes a very long way indeed, appearing finally in the form of that curiosity which creates science and gives and promises us supreme, unlimited orientation in the surrounding world.*

It is on the basis of orienting reflexes—which subsequently take the form of an active investigatory reflex in relation to every new thing—that the child becomes acquainted with the activity around him and forms his first images of the objects of reality. On the basis of orienting reflexes, which at first have the character of passive orientation, there arises the conditioned-reflex way of active search of the object in one of its forms (turning the head to a voice at six months); grasping movements develop on the basis of this, and from these all possible manipulative hand-movements with the object. It is also, presumably, on the basis of the orienting reflex that the child develops connections between those different properties of one and the same object which underlie the formation of the image, and between the properties of an object and the means of action with it.

Since there has been practically no research into this ques-

* Pavlov-Anrep, 12.

tion, it is only possible to make assumptions about certain features. We may suppose that the connections between the separate properties of the objects with which the child has to deal are not the same as connections between the essential and inessential properties of food; the process of formation of connections between them, however, is very similar to the formation of early natural conditioned reflexes; to judge from observations, they form almost 'on the spot.' One remarkable property of the orienting reflex is that it possesses its own natural 'self-reinforcement'; that is, each new position of an object reinforces by its novelty the orienting-investigatory reflex underlying the parallel activity, and simultaneously reinforces the connections between the stimulus and action with the object. This is probably the reason why the child of 7 to 8 months can occupy itself for so long with the same object, provided this has enough possibilities of 'novelty.' Yet the orienting reflex extinguishes rather rapidly; according to Denisova and Figurin [9], extinction occurs after 15 to 25 minutes of play with an object, when a 'new' object turns into an 'old' one.

Finally, attention should be paid to the important part played by the orienting reflex in the formation of new types of temporary connections of exceptional significance to the child's development; for example, imitation, which originates with the development of the orienting reflex (29, pp. 55–56).

SUMMARY

Attention has had a long history as a psychological problem. It has been conceptualized in a number of ways; but as we have formulated it, attention is (*a*) a selective mechanism which regulates what stimuli will be received and, further, governs which forms of stimulation will be admitted to consciousness, (*b*) an integrative mechanism governing the scope or range of stimulation which will be structured into percepts, and (*c*) an act which is conditionable.

There is experimental evidence that if attention has been conditioned to certain stimuli then these stimuli can be located in a

search task more rapidly than before and they can be extracted more readily from an embedded-figurines design.

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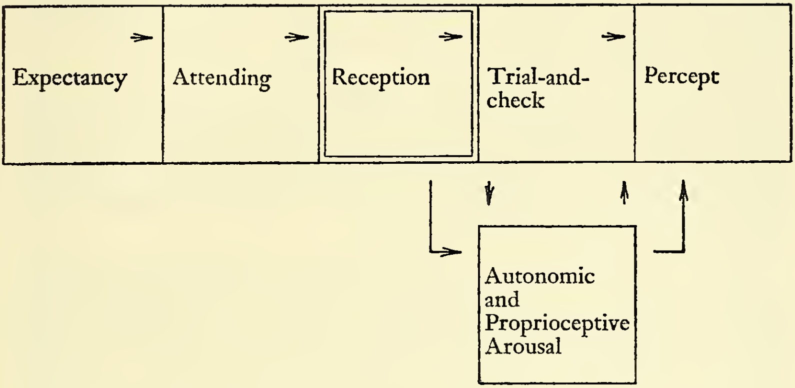
ensory Learning



From our point of view there is no sharp distinction between sensation and perception. A sensory experience is, in a very real sense, a primitive interpretation of the distal world. Some prefer to think of sensation as ready-made, wired-in perception, inflexibly tying the distal world to the neural physiology of the individual. Within the introspective framework of Wundt and Titchener it seemed to make sense to distinguish sensation and perception. But with time what was called sensation seemed more complex and more like some elementary form of perception. Indeed, Gibson's (23) distinction between literal and assumptive perception seems to be the most valid distinction worth making today.

Moreover, it does seem that so-called sensory events have a stronger immunity to change than does more complex perception. Sensations may adapt, as in dark or light adaptation to absence or presence of light, but quickly readapt to meet the immediate stimulus demands of the environment. Long-range, persisting types of "learning" are rarer, but such effects *do* occur.* And, properly, they need to be included in this book, though processes more accurately labeled sensory adaptation need not be included.

Because our conception of perceiving, as a multistage process, began with energy from some stimulus source falling upon some receptor, there is a special necessity to determine the extent of sensory learning. In effect we need to examine changes in the first stage of perceptual structuring.

First, we will examine long-range losses in sensory reactivity, usually referred to as *habituation.* Then we will explore long-range increases in sensory reactivity, which we refer to as *sensitization.* Following these more elementary forms of sensory learning, we will turn to the more complex varieties such as the conditioning which gives rise to sensory hallucinations and the sensory learning that occurs in conditioning studies. We must also make a detailed examination of Ivo Kohler's work, and studies relevant to it, since no presentation of sensory learning would be complete without such an examination.

HABITUATION

Sheer repetition of a stimulus often leads to a loss of sensory responsiveness which is fairly permanent. This is usually referred to as *habituation.* By sensory responsiveness we mean either a

* There are at least six good secondary sources which review a goodly portion of the literature in this area. Harris (26) has surveyed the literature up to 1943 on nonassociative factors, including data on various phyla; Guthrie (25, especially Chapter IV) has provided us with an intelligent conception of associative factors; and from a different point of view Maier and Schneirla (42) and Birch and Bitterman (2, 3) have also done so; Brown (8) has more recently stressed the role which sensory changes play in altering drives and the efficacy of various types of reinforcers; and Gibson (22) has reviewed a large number of pertinent studies. These six sources are "musts" for those interested in the problems of this area.

receptor reaction or a motor response which automatically follows a stimulus input, that is, an unconditioned response. A simple experiment by Humphrey (28) serves as an example. He demonstrated that a musk turtle would extinguish withdrawal of its hind legs when tapped on its shell. Taps from an electric hammer were given every two seconds. After seven trials the turtle responded less and less to the taps until it would not respond at all. The same loss of reactivity has also been demonstrated in humans (36). If the abdomen is scratched with a pin or a fingernail, there is an abdominal reflex. This automatic response decreases until it no longer occurs upon continued repetition of the stimulus. Even the knee-jerk response to a tap on the patella has been shown to increase in latency and decrease in amplitude with repetition of the tap (13).

In addition, nystagmus, the overt reflex initiated by labyrinthine stimulation, shows a decrement in a variety of experimental conditions (*e.g.*, 14, 43, 44). Also, startle reactions to intense and sudden stimuli decrease with repeated application of the stimuli (36, 51). Even *GSR* reactions to loud noises (11) decrease with repetition of the noises; and a decrement in *GSR* has also been found on repetition of emotionally loaded words (60). All of these studies support the proposition that repeated application of some stimuli to an organism *reduces* the strength of the unconditioned response or reaction to those stimuli. This proposition does *not* include all stimuli nor all reactions, but it does state that one must be wary of habituation effects. Habituation is particularly likely to occur if (*a*) the stimulus is repeated at short intervals (44, 51) and (*b*) the stimulus is barely above threshold (25), although it can occur under other conditions (*e.g.*, 46).

Anyone who has used electric shock as a stimulus in an experiment has noted adaptation effects within short intervals of testing. However, it is less well known that there is habituation to electric shock as well. Harris (26) has demonstrated this in the black rat and Seward and Seward (53) have demonstrated this effect in humans. The Sewards' study is particularly noteworthy. Their procedure was to administer a weak, momentary shock to the feet of female human subjects five times a day, at one-minute

intervals. They recorded *GSR*, general body movement, thickening of the thigh muscles, and respiration. The *URs* to the electric shock showed decrements ranging from 50 to 69 per cent of the original strength.

Very little is known about *how* habituation takes place although the phenomenon is well documented. A few physiological studies (15, 40, 51, 62) provide some possible mechanisms.

Veszi (62) and Prosser and Hunter (51) have reached the conclusion that an internuncial neuron is necessary but not sufficient for habituation. Frogs, rats, and cats have been shown to display habituation of reflexes (automatic responses) if an internuncial neuron was involved, whereas reflexes which did not involve such a neuron did not show habituation. However, some reflexes which definitely involve internuncial neurons have shown no indication of habituation under apparently favorable conditions (36). Habituation can even occur through direct cortical stimulation. Dusser de Barenne and McCulloch (15) have been able to show in the narcotized monkey that habituation can be obtained by direct cortical stimulation if stimuli are extremely weak and if they are spaced over four seconds apart.

It is possible that one of the mechanisms by which sensory habituation occurs is a fairly permanent, ganglionic block. Bronk, Pumphrey, and Hervey (7) have observed that rapid stimulation of a ganglion can produce a massive ganglionic block which persists for several minutes. Although these effects are not as enduring as would be necessary for long-range sensory habituation, they are indicative of a *possible* mechanism. The findings of Lowenstein and Sand (40) are even more indicative of changes in sensory receptors as a result of repeated stimulation. Using ray fish as subjects, they placed micro-electrodes on the small hair receptors in the labyrinth. When the ray fish is horizontal there is a steady, "resting" discharge of these receptors; when the ray fish is tilted laterally, the labyrinth fluid exerts pressure on these receptors causing them to fire more rapidly. Lowenstein and Sand tilted their subjects repeatedly, observing that there was a reduction in both the resting potential and the magnitude of change in potential produced by tilting. This reduction of sensory sensitivity was of a permanent nature. Later, these investi-

gators found feedback fibers from the cortex to the labyrinth which dampened the nerve firings with repeated stimulation; this suggests that there is cortical control over sensory sensitivity.

All the foregoing seems ponderous and complex. Yet, some simple principles underlie the evidence. Repetition of a stimulus can decrease sensory reactivity which is *of a fairly permanent nature.* There even is evidence that this loss occurs at a receptor level and that it can be induced at a cortical level. From judgments of subjects in electric shock experiments we can also infer that there is a genuine loss of experience of sensation; there was a scotomatization of pain. It is *as if* absolute thresholds for some stimuli had been raised, although it is going beyond available data to make such an inference.

SENSITIZATION

Whereas habituation is the gradual loss of sensitivity due to repeated stimulation, *sensitization* refers to a gradual increase in sensory responsiveness due to repeated stimulation. There is nothing really contradictory in such a conception of these two theoretical functions. Hering, Sherrington, Pavlov, Hull, and others have postulated excitatory and inhibitory processes which are simultaneously in operation. We use the term sensitization because it is broadly descriptive of an important aspect of sensory learning. Birch and Bitterman (2, 3) use the term "sensory integration" and the Gibsons (24), the notion of "differentiation" to cover much of the same material, although "differentiation" stands out more than does "sensory integration." The Gibsons' example of the wine taster with the educated palate illustrates vividly that a closer psychophysical relationship develops between stimuli and sensation (simple perception) with repeated experience. The search for and discovery of new sensory experiences undoubtedly shows learning. In such learning there is certainly differentiation within the range sensory experience, not an increase in the intensity of a sensory experience. That is another story!

This leads us back to where we left off on the topic of habituation. The work on nystagmus, and particularly the work of

Lowenstein and Sand, might lead one to think that orientation in space gets fuzzier with practice, whereas the opposite is closer to the truth. There are a number of studies in which blindfolded subjects were tilted, in a movable chair, and were required to return to some original position. Studies by Garten (21), Kleinknecht (30), Kleinknecht and Lueg (31), Weiner (63), and Solley (56, 57) have clearly shown that, using a tilting chair, subjects gradually reduce their errors of postural perception. Reports by their subjects inform us that there is a differentiation of pressure cues, especially within buttocks, and that unless this differentiation occurs there is little or no improvement in performance. This "learning" was of a permanent nature persisting for at least two years after training (31). In none of these studies were the subjects informed as to their errors, *i.e.*, there was no knowledge of results or reinforcement in the usual sense, yet there was steady and progressive improvement in perceptual judgments.

In fact the studies we are interested in at this point have the common feature that stimuli were repeated but no knowledge of results or reinforcement was given. Eleanor Gibson (22) has summarized a vast amount of such evidence. The references cited by Gibson are too numerous to give here; yet a summary of the evidence she gleaned is in order. Studies on foveal and peripheral visual acuity, using either parallel bars or Landolt rings, show that there are large increases in acuity with practice; and the acuity of the two-point limen on the skin also increases with practice. That upper and lower limens can be extended has also been well established for auditory, gustatory (to saline solutions), and visual discriminations. Relative discriminations have been found to improve for pitch, weight, and spatial perceptions. In addition, absolute estimations of tones and visual space (area, extent, angles, depth, and distance) have been found to improve with controlled practice. As Gibson points out, there are many factors which influence these improvements. There can be little doubt that repeated practice—even without external reinforcement—can lead to perceptual improvement, but amount and distribution of practice are important, the best effects being obtained with large amounts of practice distributed over time. This

is not, however, universally true. But external reinforcement seems to accelerate the learning. More important than reinforcement seems to be the sequence of training. If subjects are given strong anchoring stimuli (*e.g.*, extreme blacks and whites), and the training progresses into the intervening series, then better learning occurs. We interpret this to mean that the use of anchoring stimuli which are clearly discriminable produces a perceptual frame of reference (as was discussed in Chapter 4) which orients the perceiver and thus makes finer discriminations more meaningful in their structure. In summary, the evidence overwhelmingly leads to the conclusion that subjects very often become more and more sensitive to stimuli, in the sense of making finer sensory differentiations, as a result of repeated experiences.

The studies by Brogden and his associates on sensory preconditioning properly belong here. From the studies by Brogden (5, 6) and his colleagues (*e.g.*, 29) we choose one by Brogden (5) to illustrate this work. An experimental group of 20 subjects was run, and a control group of 20 subjects was tested also. A 1000 cycles per second tone approximately 15 decibels above threshold was presented ten times. For the experimental subjects the overhead light in the room increased slightly in brightness when the tone was given. After this, a series of 60 trials was given, half with the tone alone and half with the light (unknown to the subject), the subject pressing a key when he heard the tone. Finally, the absolute threshold for the tone alone and for the tone in combination with the light was determined. The results showed that the experimental group's auditory threshold was lower when the light change was present. This study demonstrates that co-occurrence of stimuli occasions a later sensitization to or an association of both stimuli, a fact often referred to as sensory preconditioning or pseudoconditioning (27).

We recognize, of course, that Brogden's study (5) is insufficient evidence of sensory preconditioning by itself; the experimental controls—the experimental and control groups were not equated in terms of the frequency with which the tone was presented—were not sufficient to draw strong conclusions. However, Seidel's recent review of the literature in this area summarizes a number of studies in which there were adequate controls. The

weight of evidence indicates that if two stimulus sources are jointly attended to they become associated so that if one of them becomes a *CS* then the other may be substituted for it. As Seidel concludes: "In the most conservative sense, one might simply state that the SPC studies have given results different from those previously gotten in conditioning or those implied by any *S-R* mediational learning hypothesis" (52, p. 71).

The Guthriean principle that the last response given is the most likely to occur is very much in evidence in this area. Indeed, conditions obtaining in simple sensory studies where the stimulus environment is highly controlled are more likely to substantiate Guthrie than are typical motor learning conditions. To have sensed a stimulus property or event makes one even more likely to sense it again. To have once tasted the fullness of Southern corn mash bourbon prepares one to recognize its flavor again. To have smelled lilacs prepares one's nose to select it out again as a significant sensory event. This may possibly be related to the "canalization" process (45) by which affect-cathexis to stimuli sensitizes us to future perceptions.

It may also be possible that *concentrated* experience with colors may improve color vision. It has been claimed by some optometrists that some color-blind persons can be trained to recognize various hues which were nondiscriminable before training. Chapanis (10) challenges a great deal of this evidence, pointing out that when *new* and *unusual* color-blindness tests are administered to people who have been reported by optometrists to be re-conditioned to perceive colors, they show no change. Most research in this area is questionable. The usual technique is to administer Dvorine, Ishihara, or Holmgren tests on successive occasions during training, and it is possible that the color-blind subjects merely learn to identify minor give-away cues. Studies by Bauman (1), Dvorine (16), Lepper (37, 38), and Pronko *et al.* (50) have not been sufficiently controlled to permit the drawing of strong conclusions. However, a more recent study by MacBrayer (41) does seem to have sufficient controls. In her study Dvorine and Holmgren color-blindness tests were used to *select* subjects. Fifteen anomalous trichromats were isolated by these tests and served as experimental subjects. All

knew the purpose of the study, although they were given no knowledge of results. The "testing" procedure consisted of taking hue thresholds each day for red and green light provided by means of Wratten filters. The "training" consisted of subjects wearing red spectacles ten minutes; ten minutes with no spectacles on; and then ten minutes with green spectacles. The results showed a significant decrease in hue thresholds for both red and green lights; all 15 subjects reached the "normal" threshold in three to seven days.

MacBrayer cautiously interprets her data as showing a *possible* improvement in hue discrimination. It should be noted that anomalous trichromats can perceive red and green to a slight degree. The intense experience of pure red and green vision, as "pure" as possible for these subjects, probably provided a kind of perceptual anchoring point in memory against which subsequent experiences could be judged, very much as improved pitch discrimination can be acquired (66). The data in this area of perceptual learning are not impressive, but are highly suggestive and warrant further, careful experimentation.

CONDITIONING OF HALLUCINATIONS

Hallucinations are *percept-like* phenomena which occur in the *absence* of identifiable perceptual stimuli. As such, they belong within or on the margin of the phenomena with which this book is concerned. They can be induced by drugs, such as mescalin or peyote, by hypnosis, and other devices. Most of the time the perceiver recognizes hallucinations as different from normal percepts, though in psychoses they may not be discriminated. Even normals, such as were observed by Perky (48), may fail to discriminate a percept from a hallucinatory image.

Before Ellson (17, 18) tackled the problem of conditioning hallucinations there were several poorly documented attempts as well as many incidental observations of hallucinations that had been conditioned. Ellson's work is the most systematic approach, yet even it is far from complete. It is worth summarizing, however, as indicative of this problem area in sensory learning.

Ellson's technique was straightforward. Adult humans were used as subjects. They were instructed to press a key as soon as they heard a tone (1000 cycles per second which was varied in decibels in two decibel intervals). A light was given as a signal before the tone. As the light was paired with the tone, the subjects reached a point where they would press the key even when the tone was omitted (17). This was interpreted, with reservations, as demonstrating that the subjects had hallucinated the tone. In a subsequent study (18), Ellson "conditioned" the hallucination of the tone and then tried to "extinguish" the hallucination. *No extinction occurred.* In attempting to rationalize this result, he pointed out that if the tone were truly hallucinated then the *UCS* (the tone) was "there" from the perceiver's point of view. It was only when the subjects were *told* that the tone was not there that any of them showed extinction. The subjects who reported that they did not believe the experimenter showed no extinction, even with this knowledge.

If Ellson had only "conditioned" a "hallucination," he would not have made his point, because there are many alternative ways of interpreting his data. The key-pressing response could have become a *CR* to the light (*CS*) without any tone being hallucinated. The extinction data bear more crucially on the problem. If the key-pressing response were not mediated by a "perceived" or "hallucinated" tone, then it should have readily extinguished when the tone was no longer presented. The lack of extinction strikes us as remarkably similar to the tenacity with which some psychotics hang on to their hallucinations. A "true" hallucination is percept-like and the perceiver has confidence in the presence of a stimulus object—even if it is not there.*

SENSORY LEARNING IN CONDITIONING

In the classical conditioning paradigm there is both a *CS* and a *UCS*. We now raise the question as to what happens to the *CS* in the course of conditioning? What happens to its sensory properties as a function of association with the *UCS*? Can a *CS* with

* Our attention came too late to the contemporary Japanese studies in the conditioning of hallucinations.

normally aversive properties acquire approach properties, and vice versa? Slutskaya's classical study (55) is a simple illustration. In this study infants were pricked with a hypodermic needle just before feeding. At first there was an aversive reaction to the needle, crying, wiggling of arms, thrashing about, etc., but eventually the infants began exhibiting anticipatory feeding responses to the needle. Here the unpleasant *CS* became pleasant or bearable, or at least we would infer so.

The same fact is evident in the studies of Pavlov (47) and Liddell (39). Such noxious stimuli as electric shock, severe wounding of the skin, and cauterization of the skin of dogs lose all their aversive properties when used as *CS*s in an alimentary conditioning procedure. According to Pavlov "not even the tiniest and most subtle objective phenomenon usually exhibited by animals under the influence of strong injurious stimuli can be observed in these dogs. No appreciable changes in the pulse or in the respiration occur in these animals . . ." (47, p. 20). However, how much of this "neutralization" was due to the subsequent *UCS* (feeding) and how much was due to habituation as observed by Seward and Seward (53) is not clear, although Brown (8) infers that the subsequent feeding was absolutely necessary. (Brown does not refer to the study by Seward and Seward [53] nor to Harris' review [27].)

One does not always obtain a "neutralization" of the noxious stimulus, however; in some classical conditioning studies, summarized in Murphy (45, pp. 199–204), the opposite effect is observed. A conditioned stimulus which ordinarily elicits a vegetative response comes to evoke aversive reactions. Which effect takes place is predictable from a knowledge of *dominance* relationships. For example, if a dog is given meat powder and electric shock at the same time, he will make strong aversive actions and not salivate when the shock is extremely strong; but if the shock is decreased there will be a point where the dog will salivate and show no aversive actions. The salivation responses and the aversive actions are in a dominance relationship to one another, and the direction of that relationship determines the outcome.

As to instances in which a neutral *CS* acquires secondary reinforcing properties as a function of association with a pleasant

UCS, there is a wealth of examples. The classic example is, of course, Bugelski's demonstration that a click, which precedes food and eating, acquires reinforcing properties, probably as a generalization of the reinforcement effect. The moral of all these studies is a simple one: the *CS* acquires some of the properties of the *UCS* as an excitatory stimulus. This does not necessarily mean that a subject perceives the *CS* as the *UCS*, nor does it imply that classical conditioning is nothing more than sign substitution. It only implies that the *CS* is perceived *differently* following classical conditioning. In all likelihood the *CS* is perceived with greater attensity, *i.e.*, the subject comes to carry out more intense attentional acts toward the *CS*. It acquires "expectancy" properties and if partial reinforcement, with the *UCS*, is introduced the man or animal may exhibit anxiety and strain, and further conditioning may be impossible (4). Thresholds for the *CS* may decrease, as observed in the decrease in generalization with increase in length of training. This is sheer speculation, for no one knows for sure, although Woodworth (65) makes a good case for changes in perception of the *CS* in classical conditioning.

Our argument is that there are changes in both "literal" and "meaningful" perceptual aspects of the conditioned stimulus. With Woodworth (65), we contend that the first thing reinforced in classical conditioning is the perceptual act involved in perception of the conditioned stimulus. It is only *after* this takes place that the *CR* begins to occur and can be reinforced by the *UCS*. There is a lag between perceptual learning and response learning.

This is the argument put forward by Maier and Schneirla (42), Birch and Bitterman (2, 3), and Woodworth (65), and Pavlov (47) himself theorized similarly. That is, in Spence's (58) terms, *S-S* learning precedes *S-R* learning in classical conditioning experiments. Without making this assumption, our own position is that *both* types of learning do occur. Of particular interest to us, at this point, is the *S-S* learning that may occur in such studies. Woodworth's analysis begins with the query: How can the *CR* be reinforced by the *UCS before* the *CR* occurs? Something is reinforced before it occurs, and the question is *what*. The answer Woodworth gives is that the perception of the *CS* is reinforced.

Or as Maier and Schneirla, Birch and Bitterman, and Pavlov phrase the answer: The *CS* acquires excitatory potential by virtue of its association with the *UCS* which is basically excitatory to begin with. The *CS* acquires "perceptual meaning" through contiguous association with the *UCS.* Woodworth says:

> As to connections, several may be established before the conditioning is *complete*, but the primary one connects the conditioned stimulus with the *meaningful* character it acquires as the first event in a regular sequence. The subject in a conditioning experiment does not have to learn how to salivate or half-close his eyes. *The new learning, the conditioning, is sensory and not motor.* The change that takes place in him during the process of conditioning is a change in his way of receiving, or perceiving, the sequence of stimuli and especially the preliminary or conditioned stimulus (65, pp. 121–122). [ITALICS OURS.]

It *may* be possible to interpret all the evidence assembled by Maier and Schneirla (42) and Birch and Bitterman (2, 3) in terms of *S-R* learning theory. The evidence is not uninterpretable in terms of *S-R* theory. It is merely embarrassing for the present; although this may not be true as evidence accumulates, at present we must conclude that *S-S* learning is a very real possibility.

THE INNSBRUCK STUDIES

What does the world look like upside down? A ridiculous question? No, it is a very serious research question. The stimulus pattern which falls upon the fovea of the eye is upside down, being inverted by the lens of the eye; yet it *appears* right side up. The question is: Why does it appear right side up? The attack on the problem has taken two directions: there are those, such as Sperry, who have explored the neuroanatomy involved in vision and there are those (*e.g.*, 9, 19, 32, 33, 34, 49, 54, 59) who have tackled the question as a problem of learning. Because our approach is more psychophysical than psychophysiological, we will concern ourselves here with only the former approach. The

importance of the question lies in what it tells us about why things appear the way they do.

An early experiment by Stratton (59) began the attack. Wearing prisms that inverted received stimuli before they were reinverted again by the lens of the eye, Stratton served as his own observer. As he reports his experiences, he was confused at first, found it difficult to "see" at all, and had difficulty adjusting movements of walking to what he did "see." In time these effects wore off and he found he could "see" and coordinate his movements with what he "saw." However, he could not decide if things looked "right." If he compared what he perceived with his memory of how things looked, he knew his new perceptual organization was *different* but not necessarily "right."

Later studies by Ewert (19) and Snyder and Pronko (54), among others, corroborated Stratton's original observations. In particular the initial difficulty in visuo-motor coordination and the "development" of better coordination with practice was noted. Snyder (54) even "learned" to drive a car and swim while wearing inverting prisms. He also ran into the same dilemma found by Stratton, *e.g.*, a person diving off a diving board into a pool appeared "natural" until he compared what he perceived with his memory of similar scenes.

No solution of the problem as to how we see things upright seemed possible until Ivo Kohler's * brilliant and ingenious research—the Innsbruck studies—appeared. Kohler's solution was to use half-prisms, *i.e.*, prisms which inverted only half the visual field. In some of his studies (33, 34) the upper half of the visual field was inverted while the lower half was not; in others (32), half of the visual field was reversed but was not inverted; and in others, reported elsewhere (33), the right and left halves of the visual field were colored blue and yellow respectively, and without inversion or reversal of the visual field.

A careful phenomenological description is given of what was observed, although there is a poor presentation of statistical data. Initially, when Kohler looked upward he distorted the visual field and when he looked downward there was no distortion. At

* For a brief English summary of Kohler's work the reader is referred to Werner and Wapner (64).

the end of fifty days, however, there was only a slight distortion when he gazed upward and a great distortion in the *opposite* direction when he looked down. It took about forty days after removal of the prisms for the downward distortion to disappear. A number of visuo-motor tasks were used, but the perceptual aspect was stressed. For example (33), when typing, the keys looked normal at first and when looking at what was typed the typed lines seemed to diverge and distort. With continued practice, however, the typed lines seemed "normal" and the keys were misaligned.

The colored lens experiments are equally fascinating. In these studies, subjects wore glasses twenty to sixty days. These glasses were not prisms; they were made out of plate glass. Each eyepiece was blue on the left half and yellow on the right. Everything looked blue when looking to the left, and yellow when looking to the right. When a subject shifted from looking left to looking right, the field appeared intensely yellow. This was produced by both the yellow lens in that part of the field and the negative afterimage of the blue. As the subject wore these glasses longer and longer he stopped experiencing an "intensification" of hue. However, the most interesting effect came after the subject quit wearing the glasses. For several days an eye movement to the right produced a yellow color, and conversely an eye movement to the left produced a blue color. We would infer that the proprioceptive stimulation from these eye movements had become conditioned stimuli for eliciting a perceptual act of seeing either yellow or blue.

What do these ingenious studies tell us? They inform us (*a*) that the way we perceive things is dependent upon the amount of experience we have had in structuring stimulation and (*b*) that perceptual acts become conditioned to stimulation produced by movements of the observer. The implications of Kohler's work are vast indeed.

SUMMARY

There is substantial evidence that aspects of the perceptual act which involve sensory reception become altered through repeti-

tion. The effects of practice are severalfold; repeated receptions of stimuli produce seemingly antipodal results. In some cases there is perceptual habituation, in which the individual becomes increasingly less sensitive to the repeated stimuli; in others, there is finer and finer perceptual differentiation. We still do not know how these antipodal effects take place; only further research can give us the answer. In addition, Ivo Kohler's research tells us that perceptual acts can be differentially associated with specific overt response patterns.

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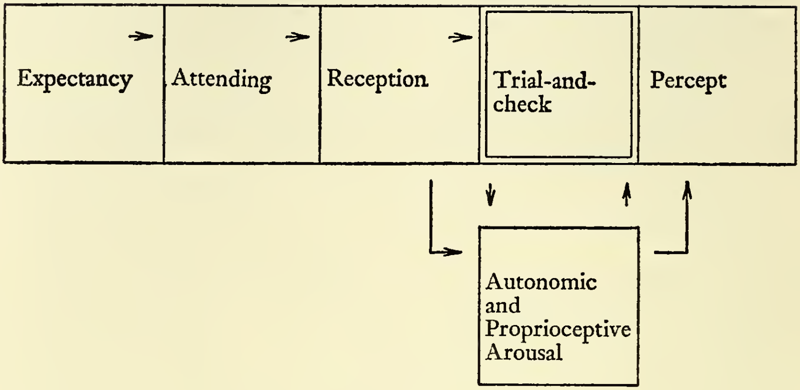
II

Trial-and-Check



Between reception of a stimulus and the final structuring of a percept there is a short but detectable time lag. This brief interval is filled with one of the most active phases of the process of perceiving, that is, the activity of structuring the percept. The perceiver's expectancies would come to naught; his acts of attending would cease; his internal cues from autonomic and proprioceptive sources would be of no avail, if there were no process of trial-and-check, no active continuity of expectancies, attention, and feedback into some final structured form, usually in consciousness. Trial-and-check is the analyzing and synthesizing process (31) by which tentative assumptions and sensory input are structured into percepts.

Our readers may wonder why we choose the term "trial-and-check" to identify this phase of the perceptual act rather than the more modern term "hypothesis testing" which has been proposed by Bruner (7) and Postman (25) and endorsed by Allport (1), especially since we shall have to rely heavily upon the research sparked by the Bruner-Postman team. We also shall have to rely heavily upon the transactionalists' research; yet we try to avoid using their concept of "unconscious assumptions." The transactionalists and Bruner and Postman have tackled the intricate problems in this area with ingenuity and persistence. Since we are relying so heavily upon their research, why not use their terms? We avoid their terms primarily because there is real value in choosing more neutral terms, as well as terms more descriptive of the underlying activity. More specifically, Bruner and Postman's "hypothesis theory" reminds us of the dilemma begun by Helmholtz (14) with his concept of "unconscious inference," *unbewusster Schluss*. The transactionalists are even more involved with that classical dilemma. History may eventually prove that there is no danger and that Helmholtz was basically sound, but at present there does not seem to be any way to express the concept of "unconscious inference" without being accused of being mentalistic or of invoking a "pre-perceiver." However, we believe there is more than just an element of truth in the concepts of Helmholtz, Bruner, Postman, and transactionalists such as Ames, Cantril, Ittelson, and Kilpatrick; the problem at hand is how to garner together the kernels of truth and to give these kernels a firmer soil in which to grow.

The term we have chosen to carry out this function is *trial-and-check*, a term proposed by Woodworth in 1946. In his words:

> When a new percept is in the making—when an obscure stimulus-complex is being deciphered, or when the meaning of a cue or sign is being discovered—an elementary two-phase process is observable. It is a trial-and-check, trial-and-check process. The trial phase is a tentative reading of the sign, a tentative decipherment of the puzzle, a tentative characterization of the object; and the check phase is an accept-

> ance or rejection, a positive or negative reinforcement of the tentative perception (32, pp. 123–124).

This is a vivid description of the phase of the perceptual act with which we are now dealing. It is terse and to the point. And it is packed with implications which need further analysis.

A FURTHER ANALYSIS

Woodworth's short description of the trial-and-check phase has many implications. It is implied that the perceiver is motivated to seek meaning, to bring perceptual order out of stimulus chaos. Unless men were motivated to create an orderly universe in perception, there would be no functional utility in perceiving; man would receive stimuli and react solely to their aspects rather than to their "meaning." There would be a 1.00 correlation between stimuli received and overt responses; or worded differently, there would be a direct connection between stimulus input and response output. In Gibson's terms, *why* should man create an "assumptive world" rather than be content with a "literal world?" At the present state of learning, we cannot explain this. We can only observe that it seems to be in the nature of man that he is *not* content with a literal world, that he is capable of building a world of meaning in perception, and that he is motivated to fulfill his biologically achieved capacities. A meaningless world would be like the world described by Tweedledum to Alice in *Through the Looking Glass* when he interpreted Alice's existence as merely part of the Red King's dream. As Tweedledum said to Alice: "If that there King were to wake . . . you'd go out—bang!—just like a candle." All men are motivated to find meaning, although few dare, as did Alice, to go through the looking glass.

It is also implicit in Woodworth's description that early perceptual learning contains more trial-and-check than does later learning. The infant cannot focus his eyes immediately; he obtains enough visual information to inform him that something is "out there." He tries to focus his eyes; he fails, and tries again and again until the stimulus is clearly in focus. The infant's first

job is not to seek meaning necessarily but to learn to receive stimulus information optimally. As "meanings" * accrue, the infant, and later the child and the man, may be said to seek meaning in perception. Just as there is less trial-and-check necessitated in well-illuminated, highly structured environments than there is in poorly illuminated, destructured environments, so is there less undirected trial-and-check at the adult level than there is at the infant's level. Whereas the young infant may take many seconds to focus his receptors for optimal reception, the adult may take scarcely one tenth of a second. Whereas the young child sees many things for the first time for which he has no ready-made meanings, the adult sees few things for which he has no available meanings.

All of this leads up inexorably to the next point, that there is an implicit, logical connection between the acts of perceiving and the acts of memory. In Koffka's (18) terms, there is an articulation between incoming perceptual processes and previously laid down memoric traces. Perceiving does not take place in a psychological vacuum. The past, the present, and the future *conjoin* in the act of perceiving. Expectancies and intentions (the psychological future); memories, judgmental frames of reference, and schemata (the psychological past); and immediate, fresh stimulus traces (the present) conjoin in the structuring of a percept. Fresh perceptual traces are tentatively assimilated into the immediately dominant memoric schemata. If they do not "fit" into the immediately dominant schemata, more trial-and-check follows until a memoric trace system is found into which the perceptual traces can be articulated meaningfully. It seems as if percepts would have no meaning unless there were some articulation between perceptual and memoric activity. Indeed, this is substantially true as we ordinarily think of "meaning."

The dimensionality of perception, however—*e.g.*, figure-

* The entire problem of what is "meaning" has been partially avoided, but not escaped, in this book. The unsolved problems of meaning and of consciousness are too vast to cope with here, if they can be dealt with satisfactorily at all in psychology's present state of ignorance. We assume that our reader's understanding of the term is sufficiently like our own to permit communication, although we will have to tackle these problems to some extent later (see Chapter 14).

ground, colors, tastes, odors, intensities of experience—constitutes some primitive form of meaning. To experience a color such as "red" for the first time is meaningful in the existential sense. The literal aspects of perception carry some form of experiential meaning. One does not merely recall objects; one recalls colors, odors, and the perceptual dimensions of an experience. One recalls not only that he saw a new rose in his garden; he recalls that the rose was a lovely shade of pink, that it had a tantalizing odor, that its petals were delicately curved. In short, incoming sensory information articulates both with memories of objects with meaning and with the literal aspects of those objects. Perhaps this is the reason why the classical subtraction time experiments failed, why an observer can report the "meaningfulness," the identity of objects, faster than he can report sensory attributes of the objects. To report sensory attributes involves a decomposition of experience whereas to report "meaning" involves a more natural differentiation and integration transformation.

Still another implication to be drawn from Woodworth's description of trial-and-check is that there is internal feedback from tentative perceptual structuring to reception in subsequent "trials." If the tentative percept is negatively reinforced, a new "trial" must ensue normally. If a man cannot see an object clearly he will focus his eyes in a different way; if he cannot hear distinctly he will turn his head to receive auditory stimuli more adequately. To decode his incoming "information" he may have to seek supplementary information. We believe that the chief weakness of the tachistoscopic method of studying perception, particularly when extremely brief exposures are involved, lies here. A presentation of a perceptual stimulus at .01 or .02 seconds does not permit the perceptual act time enough to complete itself fully. In tachistoscopic presentation, memory and expectancies play a more important role and feedback plays a less important role than they normally would. There can be little or no trial-and-check in such procedures. At best there can only be a tentative trial-and-check.

The last implication to be drawn from Woodworth's short de-

scription is that the final phase of the perceptual act, the structuring of the percept, is either a positive or a negative reinforcement. Of course, we have already encountered this idea, that percepts function as internal reinforcers. The percept takes the perceiver away from the last perceptual activity that he was engaged in and completes the act. Reinforcement could come about in this way. Or it might come about from the gratification one obtains when he achieves a clear and structured percept. Or tentative perceptual acts could be reinforced, positively or negatively, by being assimilated into or rejected by some meaningful memoric schemata. This too could lead to gratification. For a percept to "acquire" meaning by its articulation with memories is to reinforce it: the articulation gives knowledge of results to the perceiver. Conversely, it is punishing to observe one's act being cast out from the sphere of meaning. Trial-and-check functions to give meaning to perceptual traces, and by so doing it completes the perceptual act with its reinforcing role.

In an article (22) by one of us (G.M.), a table suggested by J. E. Simpson verbally described a sequence of trial-and-check. The table was used to illustrate the flux of perception and memory, along with autonomic and proprioceptive feedback, affective results, and reinforcement.

As suggested by this table, some veridical information occurs on each successive "trial"—a fact substantiated by Bricker and Chapanis (6) for tachistoscopic measurements; even a "nonsuccessful" percept conveys some correct information. The tentative percepts arouse affect which may facilitate or impede subsequent "trials." There must be a feeling that something is "not quite right" since the perceiver continues making "trials" until the correct percept is achieved. It is as if a poor articulation between perceptual and memoric traces might lead to rejection of the tentative percept; just as two competing responses may weaken one another, so competing perceptual and memoric acts may impede one another and lead to a momentary reduction in the strength of both, giving rise to the next memory and percept in the hierarchy. Thus negative reinforcement occurs in the "check." If the two—perceptual act and memoric act—

agree with one another, then they facilitate one another giving increased strength to the percept. This would be a case of positive reinforcement.

In general, Helmholtz's *unbewusster Schluss*, Woodworth's trial-and-check, Bruner and Postman's hypothesis testing, Titchener's core-context theory (see 5), and the transactionalists' assumption hitching are all attempts to answer a basic and perplexing perceptual problem. The problem is: How does perception become meaningful? Why is it that we see a world of things rather than a world of edges, surfaces, textures, gradients, hues, and so on? As a problem, this goes back to Locke, Berkeley, and the Mills, of course, and to Kant and Herbart. In the Gibsonian frame of reference the question would be: How does the world of literal perception get transformed into the world of assumptive, meaningful perception? *Unbewusster Schluss*, trial-and-check, hypothesis testing, assumption hitching and unhitching, and cell assembly formation are merely hypothetical mechanisms which have been invoked to explain how this transformation takes place.

Every percept may be said to have two components, a sensory and a "meaning" component, which often blend together as in physiognomic perception. The transformation which takes place between reception of a stimulus and the final structured percept may, accordingly, best be thought of as two transformations. The perceptual act certainly has two functions and it is heuristic to conceptualize the intervening process as two transformations. Penfield and Rasmussen (24) seem to have demonstrated that separate storage systems may exist in the cortex for the purely sensory aspects of perception and the more meaningful aspects. As they probed the brains of conscious patients, at certain spots they obtained reports of purely sensory experiences devoid of any meaning other than the experience of sensory qualities, and at other spots reports of "thing" events.

Although trial-and-check does refer primarily to the transformation which provides meaning, it must also provide sensory structure. The "sensorial transformation" includes what Bruner and Postman (8) have referred to as an autochthonous process. The physical energy from the perceptual stimulus is transformed

into electro-chemical energy at the receptor; the ascending nerves, *e.g.*, the eighth cranial nerve, and way stations such as the thalamus further transform the coded energy; and the projection areas provide a further transformation. These transformations provide the dimensions of a percept, *e.g.*, the perceived tones, textures, and colors, which are the literal aspects of the world about us.

This position puts us squarely in the camp of Scheerer (27), Köhler (19), Koffka (18), Helmholtz (14), and Müller (21). (Also see O'Neil [23].) We believe, as did Johannes Müller, that we do not consciously perceive what is "real and out there" but what our nervous system is doing. As Müller says: "Sensation consists in the sensorium receiving through the medium of the nerves, and as the result of the action of an external cause, a knowledge of certain qualities of conditions, not of external bodies, but of the nerves of sense themselves" (21, p. 1065).

In normal, intact persons, both "sensorial" and "meaning" transformations simultaneously take place. The physical energy of a stimulus source is decoded, or if you prefer, "recoded," simultaneously into experiential qualities and other forms of meanings. As Allport summarizes this idea: "Percepts always contain an awareness of the identity and characteristics of what we are perceiving, a component of *meaning* that accompanies the bare sensory experience" (1, p. 532).

Interwoven with the problem of perception and meaning is another equally complex problem, that of perception and consciousness. The language of perception is, metaphorically, the language of consciousness. Although trial-and-check is considered as the operation which is performed by the individual to structure a percept, nothing need be said about the fact that the percept is in awareness. However, whether or not *explicitly* stated, consciousness is involved. (We shall consider the problem of consciousness and perception in more detail in Chapter 14.)

The amount of trial-and-check necessary for the structuring of a percept goes up as the level of awareness goes down, and it seems to decrease as awareness increases. For example, on a foggy day it is difficult to see very far ahead while driving. A dark object ahead, which is poorly visible, cannot be immediately

identified; we are barely aware that there is something on the road and consequently we make several trial-and-checks, testing a number of tentative assumptions, seeking perceptual structuring. We focus and refocus our eyes; we make small adjustments of head and body to get a better reception; we repeatedly sample from the environment until we achieve a stabilized percept.* In a sense, trial-and-check normally brings the structured percept into awareness. Titchener could argue, in his day, that clarity was an attribute of perception; but many psychologists today hesitate to admit consciousness into psychology as a legitimate problem. Some behaviorists such as Skinner (30) have tersely condemned their fellow psychologists for avoiding the problem of consciousness which Lashley, Holt, Dunlap, and the early behaviorists (other than Watsonians) had begun to tackle in the 1920's. Indeed, the study of perception demands that we include the problem of levels of consciousness, and preferably within the scientific superstructure we have developed, using careful analyses of stimulus variables, of responses which are observable, and of intervening variables to anchor our concepts.

Levels of awareness are involved in perception at several stages of the perceptual act. Expectancies, for example, can be operative at several levels of awareness, although we believe with Ittelson (15) that the perceiver is generally unaware of his expectancies or assumptions. In a sense we are saying that unconscious processes operate selectively upon conscious processes. This implies that trial-and-check is the natural extension of the flux of unconscious expectancies, which "exist" prior to reception of a stimulus, into the conscious structuring of percepts. Expectancies do seem to govern what obtains initial entry into consciousness; strong perceptual expectations—especially when there are also strong intentions toward some goal—provide a sort of right of

* When one of us (G.M.) read this passage written by the other author (C.S.) he commented that he would rather have us walk than drive together if the driver does all this. However, experts on good driving practices tell us that the good driver constantly samples from his rear view mirror, his side mirror, the road far ahead, his dash panel, and so on, whereas the poor driver stares straight ahead! G.M. agrees, but thinks this goes on extremely fast or the coroner gets the evidence.

way into consciousness by determining what structures and meanings will be tried first.

The perceiver's acts of attending also influence trial-and-check activity. If an individual is attending to what he is hearing, he tends to "shut out" visual stimuli; if he is looking intently, he may become functionally deaf; if he is savoring the products of some fine French cuisine, he may become oblivious to both the visual and auditory aspects of his surrounds. In that the act of attending involves selective adjustment of specific sense receptors for maximal stimulation, the dimensionality of perceptual experience is restricted. Attending to a visual stimulus functions to make visual perceptual traces dominant over other forms of perceptual traces. We suspect that expectancy functions in such a way as to determine meaning, whereas the act of attending functions predominantly so as to determine the sensory dimensionality of perception.

This theoretical overview of trial-and-check prepares us for a review and analysis of experimental data on trial-and-check to which we now proceed.

TRIAL-AND-CHECK RESEARCH

Trial-and-check activity takes place so rapidly in adult human beings, under everyday life conditions, that special means must be taken to slow it down. By slowing it down, the investigator has time to study it. Nearly all the researchers in this area have had to resort to what may wrongly be called "tricks." In general, the procedures have consisted of presenting the perceiver with environments which he does not expect or which he has never encountered in the past. Of course, one could manipulate or induce expectancies by instructions or preparatory sets, and this technique is used sometimes, but such studies are generally focused upon how expectancies are related to percepts; the investigators ordinarily do not interpret or analyze their data in terms of trial-and-check. Spontaneous comments or behaviors which serve as indicators of trial-and-check activity are not recorded; or, if recorded, not published.

Research on trial-and-check, then, falls into two broad groups; either expectancies have been experimentally built up and their effects tested in ambiguous environments, or "normal" expectancies have been utilized and ambiguous environments have been used. In both cases stimulus environments have been used which are susceptible to several perceptual interpretations. The research in this area can be divided in another way. Since the bulk of this research was done either by the transactionalists or by the Bruner-Postman team, we divide the research into that done by these two groups. For convenience we shall begin with the transactionalists.

Transactionalists' Research

The man responsible for a large share of the experimental instrumentation for this group is Adelbert Ames (3). His technique has been to build apparatuses which present stimuli that are radically different physically but are identical at the receptor level. He rigged the experimental setting so that two distal stimuli (not in direct contact with the body) are different but yield identical proximal stimuli (stimuli directly active on the body). In such a set-up the perceiver's normal assumptions or expectancies are operative. In order to keep a perceptual balance—a perceptual homeostasis, so to speak—the perceiver checks what he receives against those assumptions.

Two of the most dramatic demonstrations devised by Ames are the trapezoidal window (2) and the "distorted" room (16). The "distorted" room is built so that when viewed monocularly it appears to be an ordinary room, but in fact one side is longer than the other and the rear wall is trapezoidal in shape. A child standing in one corner will appear to be taller than an adult standing in the other corner. A photograph of the room is shown in Figure 13.

Since the room is perceived as an ordinary room, the perceiver is led or "misled" into perceiving normal objects within the room as distorted. When the perceiver has to touch a block of wood within the room with a long pointer, he misses and has to make new "trials." With practice at this task the perceiver achieves accuracy in touching blocks of wood placed about the room.

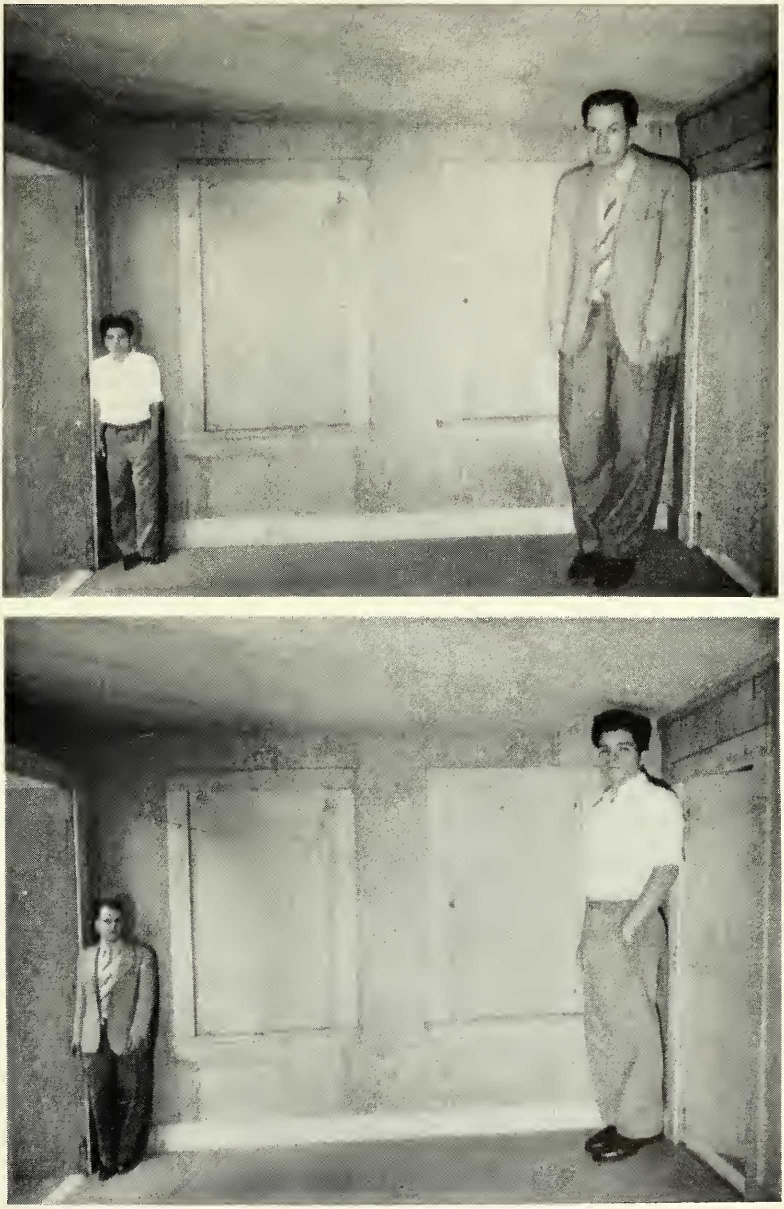


FIGURE 13. *The Ames' distorted room. Although the room appears to be "square" or normal, it is actually distorted with the far left corner considerably farther away than is the far right corner. Since the observer "assumes" the room is normal, he perceives the people as freak midgets or giants.* (Photograph furnished by the Institute for Advanced Research, Princeton University.)

This practice leads to the development of new "assumptions." When he is moved to a new room, which has also been distorted, the perceiver transfers his acquired perceptual frame of reference; that is, his newly acquired assumptions are transferred so that his methods of making trials and checks are transferred.

In Kilpatrick's research, the subject seats himself in front of a miniature room which is actually an inverted truncated pyramid. Viewed monocularly, this appears to be a cubical room, since the projections on the retina from this particular three-dimensional shape are identical with those of the cube as seen from the same point; and it is the cube rather than the inverted truncated pyramid which would be preferred on the basis of any modern conception of perception, whether nativistic or empirical. The subject must now throw a ball to hit a spot of light played about by the experimenter in the miniature room. After only thirty or forty minutes of experience in seeing how this ball bounces, and where it hits its target, the room has been to some degree transformed in the direction of becoming an inverted truncated pyramid.

Two types of learning have been distinguished in such situations by Kilpatrick (17). In the case of *A*-learning, the perceiver learns to pick up "give-away cues," such as nails which have not been completely covered by paint or unusual shadows; in the case of *B*-learning, he learns new methods of making trials and checks. Since the give-away cues are different in the two rooms, the latter type of learning is the more probable basis for the transfer of training.

The *A* method of learning would be useful if the subject were to try out his way of perceiving another miniature room. Consider, however, the following: The experimenter now directs the subject to another miniature room which again is viewed monocularly through a small hole. This latter room is actually a true cube. The subject, however, sees it more or less as a truncated inverted pyramid! The subject has shown perceptual "transfer," by virtue of the training he received with the first room. Now we cannot argue that this is another case of Learning Type A based on learning to take advantage of give-away cues. On the contrary, the subject now sees the truly cubical room as if it were

the room with which he has just had this experience. Any give-away cues would actually train him now in the wrong direction! Plainly, what he has learned to do is to recast, organize, or emphasize the multiple cues from stimulation of the retina by this system of lines and surfaces, and he responds by "analogy" as Woodworth would say; that is, he gives meaning to Room No. 2 to make it as much as possible like Room No. 1. This matter of reorganizing, re-emphasizing, giving fresh structure to proximal stimuli in such a way as to give a total result which has been built into the subject, is Learning Type *B*. There is a great deal of Type *B* learning in our daily lives. We force the stimulus materials, impinging upon our sense organs, to give a result which we are used to or which we want.

There is a fairly simple demonstration that one can build for himself which has many of the same properties as the distorted room. Twelve pieces of 1/16″ balsa wood (obtainable at any model airplane store), each five inches long, can be glued together to form a cube. Next they have to be painted black and the cube placed in a uniform light setting, such as on a lightly colored rug. Thus, one has a three-dimensional Necker cube. When viewed monocularly (it will work when viewed binocularly, but not quite as well) the cube will reverse perspective. The perceiver can then walk slowly to one side and the cube will appear to rotate. Curiously, when perceived in its normal perspective the cube will remain stationary. Figurines placed in the cube or suspended from it with small threads will also distort as the reversed cube rotates. The figurine will appear to get bigger, then smaller, as the three-dimensional cube reverses perspective. If the observer moves around the room while perceiving the reversed perspective of the cube, the suspended figurine will twist and bend just as the cube appears to be doing. As with the distorted room, if the perceiver's normal trials and checks do not agree with what he perceives he must develop new methods of trial-and-check to restore perceptual equilibrium, even if it means distorting the figurines within the cube.

The trapezoidal window is another dramatic demonstration. The trapezoidal window rotates, and as it does it appears to oscillate because the perspective shifts which occur with rotation

do not "fit" into the perceiver's normal process of trial-and-check of assumptions. A rigid tube placed through the window will seem to bend at the ends and pass through the window. Again, this seems to occur to keep a perceptual balance with the situation. If the perceiver is told that the tube is made of metal it will appear to cut through the window, sometimes to the amazement of the perceiver. It is frequently observed, in this demonstration situation, that the perceiver reports feeling anxious and upset, as if he could really not believe what he is perceiving. He has neither assumptions nor memoric traces into which the perceptual information "fits" perfectly, and as a consequence he becomes anxious and upset.

A device similar to the preceding techniques is the use of aniseikonic lenses. An ordinary room, the walls and floor of which have been covered with leaves, is viewed through glasses comprising one or two aniseikonic lenses. (Other investigators, *e.g.*, Simpson [28], have used similar glasses in a room draped with black cloth and straw on the floor; both types of room produce the same effect.) Although the lenses distort the proximal stimulus upon the retina of the perceiver, he does not immediately perceive the room as distorted. His own normal trials and checks maintain a percept of a normal room for a time. In fact, some perceivers report that the distortion takes place in stages; the room seems to "give" slightly, becoming slightly distorted, and then "gives" again, and again, as if the perceiver were successively attempting new trials and checks in order to cope with the proximal stimulus. Each time the glasses are put on, after rest periods, the distortion takes place with shorter latency as if the trial-and-check had become simplified and strengthened.

Simpson (28, 29) has also shown that aniseikonic produced distortions associated with pleasant music are accepted more readily than are distortions associated with an unpleasant noise. This effect showed up in reduced reaction times and in degrees of distortion produced after the music associations were made. However, these data are not as reliable as they might be; Simpson reports (29) that he failed to get these results with college sorority women although he did find these effects with secretarial students.

Still other research (15) has dealt with the trial-and-check which accompanies space perception. One fascinating technique is the use of balloons which get larger or smaller (by compressed air being fed in or let out) and brighter or dimmer by varying their illumination. As the balloon gets smaller or dimmer it is perceived as moving away, whereas if the balloon gets larger or brighter it is perceived as moving closer. Of course, the perceiver's normal assumptions are that smallness and dimness are cues for increasing distance from him. When the balloon gets smaller but brighter, or larger but dimmer, the perceiver is often confused and baffled since he has not learned any trial-and-check which deals with comparable situations.

A more recent technique has been used by Engel (13). This consists of using stereoscopic presentations. Two figures are used; one is presented to one eye of the perceiver, and the second, to the other eye. In an experiment using this technique, statues of a nude and of a fully clothed person were used. Some observers reported seeing the nude statue first and then to their amazement they saw the nude statue put on clothes; other observers saw what appeared to be a strip tease in which the clothed figure took off its clothes. Apparently, under these conditions trial-and-check is so active that something resembling movement was perceived; there was a rapid shift in "trials" and the final resultant was the stabilized percept.

The transactionalists have made a brilliant contribution to this area of perception; their instrumentation has been ingenious and the effects have been dramatic. With Bruner and Postman they share the spotlight.

The Bruner-Postman Research

We turn now to the research carried out by Bruner, Postman, and their associates. We share with Allport (1) an enthusiasm for this body of research. It is firmly rooted in observable behavior; it has sufficiently anchored its concept to observables to permit deductions to be made; it has even progressed to the stage of making theorems and corollaries. We disagree with Allport (1), Bruner (7), and Postman (25) that perception consists solely in testing hypotheses and that all perception is dictated

by "sets." However, this does not detract from the value of their experiments. In general, these investigators have used simpler procedures than have the transactionalists; they have frequently used nothing more than a tachistoscope in which unusual stimuli have been presented.

A study by Postman, Bruner, and Walk (26) illustrates this point. Tachistoscopic presentations of playing cards were used in which the diamonds and hearts were black and the spades and clubs red. Perceptual reports, including spontaneous comments, were reported. Some observers reported seeing suits which matched the colors; others, colors which matched the suits; still others reported seeing some fusion of suits and colors, such as a spade which was black but which had a reddish tint. Often the first "trial" did not "work," *i.e.*, no stable percept was achieved, and the observer had to establish some stability by distorting his percepts to fit his already established schemata of how playing cards appear.

Minturn and Bruner (20) have illustrated another principle of trial-and-check. Trial-and-check seems to be responsible for making closure. They exposed either numbers or letters. Following this they exposed the ambiguous figure 13 which was perceived as *13* by those observers who had developed a "hypothesis" for numbers and as *B* by those who had developed a "hypothesis" for letters. A third group of observers who were given a mixed initial series perceived the ambiguous figure as *B* or *13* about equally often.

Blake and Vanderplas (4) have tested some of Bruner and Postman's ideas, using auditory intensity-thresholds for words. The words were presented at barely threshold levels and then were repeated at slightly higher levels until they were perceived correctly. Their results tell us that if a perceiver erroneously structures a percept at a low threshold it takes a great deal more "information" for him to restructure the percept than otherwise. Once a specific trial-and-check action has been consolidated into a structured percept it has to be extinguished or overcome by higher intensity levels, or at least by additional information.

Admittedly we have not covered all the research in this area,

just as we have not *completely* covered all available research in other areas which deal with perceptual learning or with the perceptual process. Our intention is simply to give a representative sample of research in the various areas and to integrate what is covered into a theoretical frame of reference.

ALTERATION OF TRIAL-AND-CHECK

There is the barest modicum of information available about the establishment and operation of trial-and-check behavior. Our theoretical frame of reference can provide possibilities. As we have already noted, the "check" in trial-and-check functions as a built-in type of reinforcer, both positively and negatively. However, we believe that any outside reinforcement, given at the moment a particular trial-and-check sequence is completed, provides additional reinforcement. If a fully structured percept has not been achieved—*i.e.*, even though only a tentative percept has been formed—an outside reinforcement can stop the specific trial-and-check activity that is going on and by so doing increase the probability that that particular trial-and-check will repeat itself.

The reinforced trial-and-check would occur with shorter latency as a function of repeated reinforcements. Unreinforced trial-and-checks should occur less frequently and with longer latency in the presence of the eliciting stimulus. We believe this is particularly true of the "meaning" transformation aspect of trial-and-check; it is probably less true of the "sensorial" transformation aspect, although Ellson's and Ivo Kohler's work, reviewed in Chapter 10, indicates that learning can modify the sensory transformation in trial-and-check.

SUMMARY

Between reception of a perceptual stimulus and percept there is structuring activity, which we call trial-and-check, after Woodworth. This trial-and-check activity consists largely of testing the articulation of tentative percepts with memoric schemata. Research on this activity reveals that tentative percepts are tested on the basis of the most probable articulation with memoric

schemata. If this does not "check" then the perceiver will require further sensory information or he will try other schemata until the percept is structured.

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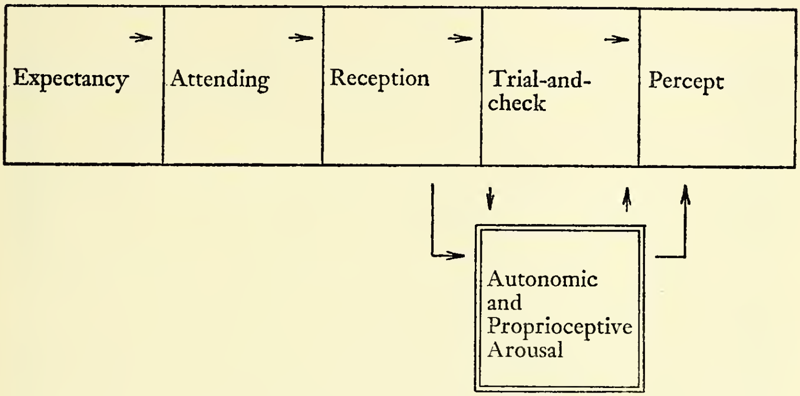
2

The Signals Within Us: Internal Scanning and Feedback



In the process of adapting to the demands necessary for survival, we are often so busy concentrating on messages from the external world about us that we ignore the signals from within our bodies. Rarely do we attend to the language of our muscles and autonomic adjusters. We ignore the protests of our proprioceptors that we are straining too hard to perceive the external world, and the feelings of queasiness—which arise when we actively distort the perceptual world to fit our needs—are quietly suppressed. Yet these are valid messages and in the long run they serve our biological needs as much as those from the outside. The purpose of this chapter is to attempt an analysis of three major problems in understanding these ignored messages.

THE CRUCIAL PROBLEMS

The three problems are related like fraternal triplets; they have the same parentage and arise simultaneously but are different enough to be considered separately. These problems are: (*a*) How are proprioception, enteroception, and exteroception linked dynamically with perception of the external world? (*b*) What role does feedback play in both stabilizing and distorting the perceptual act? and (c) How can an individual become aware, and to what degree, of such messages?

The task of answering these questions is not an easy one. Although there is a massive accumulation of knowledge and theory about perceptual-motor activity—as evidenced by the sizable bibliographies compiled by Ammons and Ammons (4)—the experimental work is extremely limited, usually to pursuit-motor activity in which the hypothetical stimulus is the "difference" between input and output. This fact alone shuts out from such theories what we usually call perception, at least as classically delineated. There are also electronic models (*e.g.*, 5, 32) as well as physiological models (*e.g.*, 11, 28), but again what is usually called perception is omitted from consideration by and large. What is needed is a conceptualization in which the conditions of learning or of association between percept and internal feedback are delineated, in which perception plays a key role, and in which applications are made relative to freeing the individual of the circularity of such feedback mechanisms. If the reader thinks we are going to supply this knowledge he will be misled, for there simply is not enough information available to do any more than outline the problems very crudely and hack away at the answers.

FEEDBACK IN LEARNING AND EXTINCTION

There are two articles in the literature which have provided us with a great amount of stimulation on these problems. Solomon and Wynne (38) have supplied some crucial experimental and theoretical information about autonomic feedback, and they hint often at how such feedback *might* become linked, through learn-

ing, with perception. The other provocative article is by Schoenfeld (31) who deals more with the role of proprioceptive feedback in learning. Neither Solomon and Wynne nor Schoenfeld deal with perception *per se* but one can apply the basic principles they discuss to perceptual learning, and we shall attempt to make such an application.

In order not to do these writers an injustice we should briefly summarize the experimental conditions they discuss. Solomon and Wynne (38) attempt to account for the extreme resistance to extinction of an avoidance response in a traumatic learning condition. Solomon and his collaborators (20, 36, 37, 38, 42) have varied the details of their studies, but their basic paradigm was the following. Using dogs, they presented a light which was followed after an interval of a few seconds by an electric shock of a subtetanizing intensity administered through a grid floor. The dog escaped from the shock by running or jumping into an adjoining chamber. After a few trials the dog avoided the shock by jumping into the safe chamber as soon as the light came on and before the shock was turned on. The problem arose in trying to extinguish this avoidance behavior.

After a few such conditioning trials some dogs would give as many as 650 avoidance responses without any further reinforcement. After several months of patient testing, Solomon and his workers grew weary and gave up trying to extinguish the avoidance response. In attempting to account for this resistance to extinction these investigators rely on some of the principles of Mowrer's (26, 27) two-factor theory of learning. That is, they assume that in a classical conditioning procedure there is first an association of autonomic arousal and feedback activity with the *CS*, and later there is an association of motor activity with the *CS*. Which portion of the autonomic upheaval gets conditioned is largely determined by (*a*) the nature of the *US* and (*b*) the *CS-UCS* interval. The autonomic upheaval is labeled "anxiety." The *CR* is maintained by a partial reduction of the anxiety level. In order to obtain extinction of the *CR*, it is necessary first to extinguish the "anxiety." However, as Solomon and Wynne (38) point out, in traumatic avoidance extinction the animal responds so quickly that the "anxiety" never gets a chance to occur be-

cause the autonomic latency is longer than that of the motor response. This means that "anxiety" is conserved. This principle of "anxiety conservation" is offered by Solomon and Wynne as a basic mechanism. Their second proposed mechanism is that of "partial irreversibility" of the response. That is, they propose that the physiochemical balance of the organism is partially and permanently shifted so that the readiness to respond in various ways is altered. Thresholds are permanently affected, at least to some extent.

If the principles of "anxiety conservation" and "partial irreversibility" are to be sound principles in such cases, there must exist *direct*, *afferent* feedback from the viscera to the cortical projection and motor areas of the organism. Such neurophysiological mechanisms have now been demonstrated (1, 2, 3, 6, 39). Further, such physiological studies also indicate that the feedback is *both* to specific and to diffuse projection systems.

Still other physiological studies inform us that such feedback from the *ANS* and proprioception facilitates avoidance learning and retards extinction, but that such feedback is not necessary for avoidance learning (*e.g.*, 42). An animal can learn to avoid the noxious stimulus even though the sympathetic and parasympathetic pathways for autonomic feedback have been blocked by surgical or pharmacological means. The same is true of proprioceptive feedback (24, 25). Although proprioceptive feedback can theoretically serve the role of a positive reinforcement or of a punishment stimulus (31), such feedback also functions to facilitate learning, but it is not essential for the *occurrence* of learning.

In quick summary, what have these articles and studies told us about feedback in learning and "unlearning"? Apparently, there are specific and diffuse feedback circuits within the individual. If the arousal of these feedback processes follows some stimulus, then that stimulus will become capable of arousing such feedback processes without occurrence of the *UCS*. But, in addition, the occurrence of such feedback will also strengthen the perception (cortical integration) of that stimulus. In the case of traumatic learning and violent visceral upheaval, however, the organism will come to "act out" so quickly that perception of the *CS* and

its associated autonomic feedback can never fully develop. During the course of traumatic learning the *CS-UCS* interval length is critical. If the *CS* occurs contiguously with the *UCS* or shortly afterward, then it will be "disrupted," *i.e.*, it will never become consolidated or structured into a full perception, as has been suggested by Smith and Hochberg (34). Another principle which seems to follow from the work of Solomon and his co-workers is that the percept gets linked or "locked" to certain specific and general autonomic and proprioceptive feedback mechanisms so that the percept and the feedback mechanism are mutually excitatory.

CONTROL OF COGNITION BY FEEDBACK

The role of feedback in developing and controlling overt behavior has been greatly clarified by Solomon and Wynne (38), Schoenfeld (31), and Guthrie (15). In these writings one finds hints as to how feedback *might* control perceiving and thinking. At this point we are much like Guthrie's rabbit hunters (15) who do not know exactly what a rabbit looks like. We must move on to treacherous terrain and, admittedly, speculate about the role which feedback plays in directing cognitive processes.

There is a simple and instructive report by Braatoy, a Norwegian psychiatrist, that can serve admirably for purposes of analysis. Braatoy (8) studied several psychiatric patients whose forearm muscles were extremely tight and rigid. Using physiotherapy means, he managed to get these muscle groups relaxed. It was noted that when this was done the patients were "flooded" with painful memories. Clinically speaking, the rigid forearms would be thought of as symptomatic of defenses. There was a focalizing of "anxiety" in the arm muscles, as in a conversion neurosis. By relaxing these muscles (symptom removal) the patients' defenses were removed and the painful memories were permitted entry into awareness.

Using Solomon and Wynne's (38) logic, we would hypothesize that certain perceptual traces in memory have been conditioned to strong autonomic feedback (probably originally elicited by some traumatic experience). To prevent full rearousal of this

"anxiety," the individual keeps part of his musculature in constant action (the constant tightening of the forearm). This is analogous to the dogs' acting so quickly that the complete arousal of autonomic feedback never fully occurs. In Braatoy's cases, however, there must be almost constant proprioceptive feedback, and indeed there probably was something similar to this going on in Solomon and Wynne's dogs. The painful memories are "locked" in a state of unawareness by the incessant feedback from the tightened muscles.

The physiotherapy on the rigid arm muscles provided a behavior (relaxation) antagonistic to the "locking" actions, an extinction procedure highly recommended by Solomon and Wynne. Of course, this was tampering with the individual's major defense—a procedure that clinically can be as dangerous as useful *unless* sufficient support can be given by the therapist in dealing with the flood of anxiety and painful memories that follows or some other therapy is taken.

Whereas Braatoy experimented on proprioceptive controls over memory, we have conducted experiments on autonomic feedback and perception. These studies were carried out by Charles W. Snyder in our laboratory. More precisely, our studies * have dealt with perceptual motor coordination and autonomic feedback.

> From a functionalistic viewpoint, perceptual-motor coordination may be thought of as a goal-directed process. As you drive down the highway, you perceive the path of your automobile getting too far to the right or left of the center of your lane and you correct it by moving the steering wheel. This activity is an example of a negative feedback system. Your motor adjustments correct for perceived deviations of your car from a center path. The whole system is directed toward the goal of maintaining a center path. This

* The next few pages are substantively the talk given by Mr. Snyder at the Southwestern Psychological Association Meeting, April 4, 1957. His presentation is so clear and concise that we could not possibly present his studies as well as he. We have made only minor editorial changes. We are indebted to Mr. Snyder for permission to use his materials.

intended path is the null of the system—the range or point at which the system momentarily stabilizes.

From what might be considered an extension of the functionalistic approach, the *perceiving process itself* may be conceptualized in similar terms. Suppose you have recently been side-swiped on the left by an oncoming car—a traumatic narrow-escape. Now you drive down the highway somewhat to the right of center, perhaps not even realizing your error. This is an example of goal-directed *perception* with internal feedback. When your path deviates to the left slightly, an increase in anxiety associated with the side-swiping incident comes into the situation. You perceive your car as too far to the left and supposedly "correct" this by steering to the right. Yet you deny that you are off center when the "back-seat driver" complains that you're driving too far to the right. This is an indication that an actual shift in perception has occurred.

We can assure you that we did not experiment with *this* situation. It does serve, however, to illustrate one way of understanding the effects of motivation on perception. We are much interested in the problem of what happens during the perceptual learning process from moment to moment. But we have only just begun to explore the possibilities here for feedback analyses.

Only one of the procedures that has been tried with a few subjects will be presented here. This was designed as a preliminary test of the notion that *autonomic cues* may somehow *trigger off perceptual shifts*, perhaps by some internal feedback mechanism.

The procedure is similar to the car-driving situation but not quite so dangerous. The subject is given the task of adjusting the height of a rectangular figure until it appears square to him. He is seated in front of a large white panel. At the center of the panel, a uniform white rectangle is displayed on the face of a cathode-ray tube, similar to a TV screen with no picture. Room lighting is reduced in order to minimize extraneous visual cues but the rectangle is clearly visible.

The subject is instructed to adjust the height of the rectangle, until it appears square, using his preferred hand on a control knob in front of him. He is shown how the height may be increased so as to make the square too tall, by turning the knob to the right, and how the height may be reduced so that the square becomes too short, by turning the knob to the left. (The width of the figure remains fixed at two inches.)

On the subject's non-preferred hand is clamped a pair of electrodes. These are for both electric shock and measurement of galvanic skin response. The subject is asked to remain as quiet as possible so that movements will not affect his palmar resistance which, he is told, is a measure of his mental effort in performing the adjustments. The electric shock is introduced to the subject before the experimental trials begin. A very brief shock pulse is given several times—gradually increasing the current until the subject reports it as unpleasant but not painful.

At the beginning of each adjusting trial, either a short or a tall rectangle is presented. The subject adjusts the figure to appear square. There is, of course, some variability in his final settings from trial to trial. When the subject adjusts the rectangle *below* a certain height and reports the figure as square, he is immediately shocked. However, the subject does not "know" he has made a constant error. By setting the rectangle above this height, he can avoid the shock. We therefore expected the subject to make the rectangle taller and taller during the series of trials, yet always perceiving a square at the end of each trial.

Five subjects have been given this procedure so far. These were female students, between eighteen and twenty-six, enrolled in a Topeka business school. *All* perceptual shifts were in the predicted direction. However, there were large individual differences, and the shift by one subject was not significant.

Figure 14 shows the results for one typical subject.

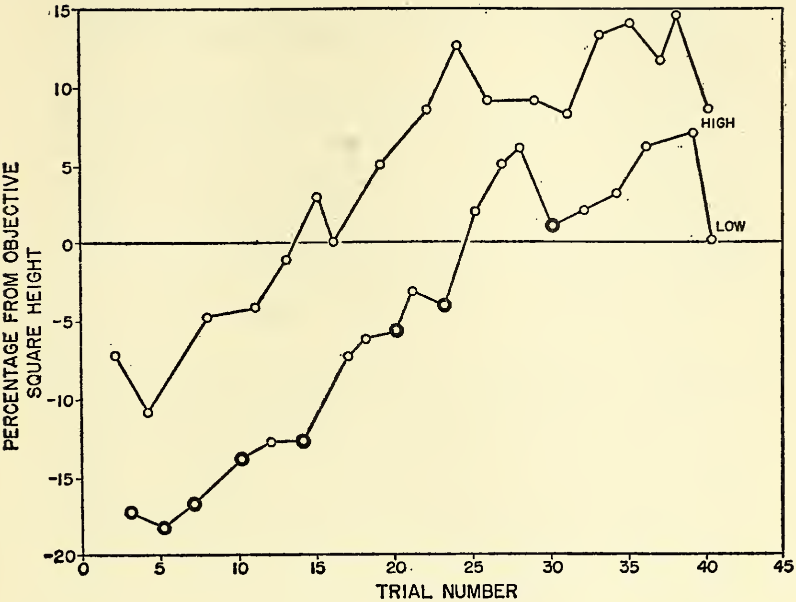


FIGURE 14. *Percentage deviation of height of adjusted square from objective heights as function of practice with intermittent shock for low adjustments.*

Height is given on the vertical axis in percentage of the height for an objective square. The objective square occurred at zero percentage where the height was two inches—the same as the fixed width. Trial number is shown on the horizontal axis. This series of trials took about 45 minutes. The upper curve is for trials beginning with high (or tall) rectangles. The lower curve is for trials starting from low (or short) rectangles. The range of variability is represented by the vertical distance between the two curves. The points on the trials when the subject was shocked are *circled.* The criterion for shock was raised by the experimenter as the subject shifted. As you can see, the amount of shift is clearly greater than the normal variability in adjustments. At the beginning of the series, the subject was setting the height under that for an objective square. In shifting

away from the shocked region of variability, the subject consistently set the square too tall, beginning with the twenty-fifth trial.

There was no evidence from interview results that this subject was aware of the association of shock with any particular adjustments that she made. She reported that there was no way to tell when shock was coming. She said she always adjusted the figure to look "perfectly" square. The interview results were the same for the other subjects.

These preliminary results seemed to indicate that our procedure was working, at least on most subjects. The effect is difficult to reconcile with traditional perception theory. The width of the square is actually an objective standard always present in the visual field during adjustment. The subject may compare this horizontal standard against the vertical height any number of times. Yet apparently the subject partially disregards these *external* cues and is *unaware* of new *internal* cues that develop in the situation.

Our central hypothesis was that, in this procedure, autonomic responses would become conditioned to the perceptual "errors" that were *followed* by shock. That is, there would be measurable galvanic skin responses while the subject was in the *process* of setting the figure to a square, even though shock was given only after certain settings had been completed.

This has been checked so far with only one subject in a slightly modified procedure. The only change was that, instead of the separate trials, the subject *continuously* adjusted the square while the experimenter altered the height of the figure with his own manual control. Galvanic skin conductance was used as an index of autonomic activity. A high relation was found between skin conductance and the subject's adjustment of the square. Nine out of 11 *positive* changes in skin conductance were found to be associated with the settings that were shocked, while 24 out of 27 *negative* changes in skin conductance occurred at settings that were not shocked. This analysis, of course, excluded the unconditioned galvanic skin response to shock itself.

A typical sequence of this subject's behavior was as follows: She adjusted the square near the range being shocked. Even though shock was omitted this particular time, skin conductance would gradually rise as the subject approached this setting. When the subject approached a setting not being shocked, skin conductance would gradually drop.

These results *tentatively* support the notion that internal autonomic cues might be triggering off the perceptual shifts that have been observed under these conditions. A more definite interpretation will have to await further experimentation.

The feedback analysis that has been developed so far is tentative and incomplete, as is the supporting evidence. Also the terminology is quite confusing unless clarified by complicated mechanical analogies. However, a brief and simplified version will be given, with illustrative examples.

One theoretical assumption is that *autonomic* discrimination of external stimulus cues may in some cases be *finer* than *motor* discrimination of these external cues. That is, it is possible to condition an autonomic response to a very small stimulus change—one that is too small to elicit a motor response.

The experimental situation is conceived of as a combination of two negative feedback systems. As shown in Figure 15, the first one is external motor feedback to the stimulus object with exteroceptive input to perceptual-motor processes.

Put more simply, this is the perceptual-motor task of the subject adjusting the rectangle to appear square. For example, if the square looks too tall, the subject reduces the height by turning his control knob to the left. He may turn the knob too far. He then perceives the square as too short, so he turns the knob in the other direction. Finally, he reaches a setting of height that makes the figure appear square. This stable "point" is the goal or null of this system.

The second system involves interoceptive and proprioceptive feedback from autonomic responses. For example, in one cycle or sequence of behavior, the rectangle may be

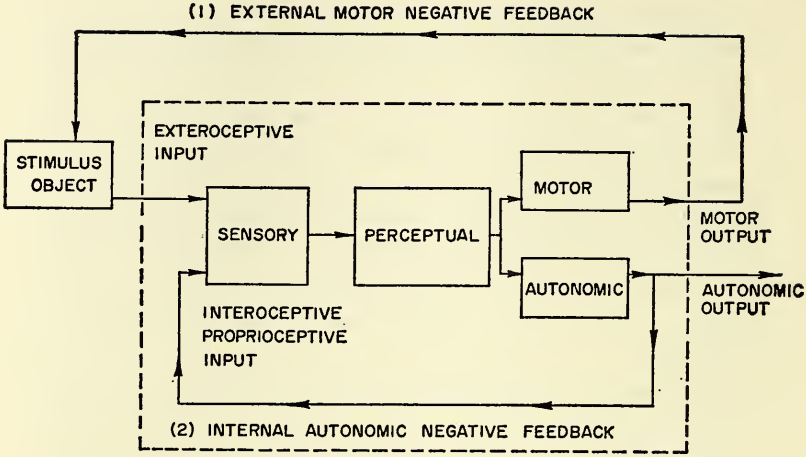


FIGURE 15. *Diagrammatic conceptualization of autonomic and proprioceptive activity as they are elicited by perception and as to how they can control perceptual activity.*

perceived as a little too short, possibly, but the subject is uncertain. If this percept has previously been followed by electric shock, it will produce an anticipatory autonomic response. This autonomic increase in turn feeds back to perceptual processes. The feedback produces a perceptual change—the subject is no longer uncertain about the square—he perceives it as definitely too short. This percept is followed by *reduction* of autonomic level. This stable point is the goal or null of this system. (The percept is also followed by a motor readjustment of the square so that it will not appear too short.)

Motor discrimination of external stimulus cues is represented in the feedback model by the range (or width) of the perceptual-*motor* null, that is, the stimulus range over which the figure is perceived as square. *Autonomic* discrimination of external cues is represented by the range (or sharpness) of the perceptual-*autonomic* null. This is the stimulus range over which the percept is associated with autonomic *reduction.* The outcome of this complicated analysis is that there will be some kind of interaction of the two systems such that a *perceptual compromise* results.

> The reader may think that this conclusion could have been reached without all of the technicalities. Descriptive models of this sort have a great deal of appeal to engineering students who have come into psychology by the back door—perhaps by once attending the wrong class by mistake. To others, feedback analysis is a regression to mechanistic thinking. And to still others, it appears to be the perfect paradigm for circular reasoning.
>
> Actually, the only theoretical problem with which we are concerned is how the concept fits the data. The vague notion of feedback has led to some interesting preliminary results and to many new hypotheses. As usual, new questions arise as fast as old ones are answered. But in the process of research, we hope to increase our understanding of the effects of motivation on perception and perhaps to develop methods suitable for correcting *abnormal* perception.

These studies by Snyder have been followed up. The results of these studies are inconclusive as yet; in general the very long reaction times of autonomic responses make it difficult to use sensory signals, which feed back from these responses, as *CS*s which serve as cues for perceptual acts. As a consequence, we have temporarily stopped this line of research and are currently focusing on proprioceptive feedback of signals (*CS*s) for subsequent perceptual acts. Dr. Arnold Gerall of Kansas University and Dr. John Santos of The Menninger Foundation are working with Charles Snyder on this new development, which is still in the preparatory phase.

A great deal of encouragement for this new line of research comes from Hefferline's experiments.* In his research (16) he found that human subjects who were allowed to observe polygraph needle deflections caused by small jaw-muscle movements (*a*) learned to detect smaller and smaller movements without the visual presence of the graph and (*b*) transferred this learning to intervening rest periods. In his unpublished research, small

* Hefferline has graciously sent us "A preliminary note on escape and avoidance conditioning of human subjects without observation by them on the response or its control of the environment," a mimeographed report of a study by R. F. Hefferline, Brian Keenan, and R. A. Harford at Columbia University.

thumb movements of subjects controlled, without their knowledge, the amount of noise being fed into music to which they were listening. By making extremely small movements of their thumbs, the subjects could "avoid" the noise which was being inserted into the music every 15 seconds *unless* they made the movements. By making these small movements the subjects could prevent the noise from occurring. After conditioning (usually requiring 25 minutes or more), an extinction series was run in which the noise was not presented, but only one subject showed extinction of the small thumb movements.

These results dramatically reveal the fine control that proprioception can have over behavior, especially behavior which shuts out unpleasant stimuli. Hefferline modestly points out that his results are tentative; a great deal of this work is necessary before we can draw firm conclusions, but the direction that research should follow is clearly indicated.

FEEDBACK AND SCANNING

We need to explore further the effects of feedback on the mechanisms involved in the act of perceiving. We begin with the active searching for stimulation, the raw material of perception.

The restlessness, the searching, the "random" but progressively more organized behavior of seeking to encounter significant objects in the environment is at the same time a motor and a perceptual process. The hands would hardly rove if they possessed no skin receptors. The body as a whole would scarcely move were it not that through moving it is in a better position to utilize its equipment of distance receptors. There are both general homeostatic factors and specific needs or sets which can sometimes be identified in relation to the seeking process. There is nothing surprising about the fact that there is readiness to perceive as well as readiness to respond when contact is made. The very fact that there is perceptual contact means that the world, as experienced, undergoes change. There is, then, a continuous cycle of feedback from the acts of perception.

The heart of the perceptual act, when considered from this

viewpoint, is the process of scanning. This involves the "aiming" of the sense organs or, indeed, of the whole body in such a manner as to present sensitive surfaces to stimulus energies. Partly on the basis of constitutional equipment like the light sensitivity of the retina, and partly on the basis of experience (*e.g.*, knowing where the flashlight is), one scans until light is encountered, and brings it into maximal capacity for foveal stimulation. We scan maximally for exteroceptive cues. But according to the present thesis we can, at the same time, scan for internal cues. We can, moreover, scan for memoric cues, as when we ask ourselves whether a present stimulus is a good match for a trace left from earlier stimulation. It is believed that all such concepts as set, expectancy, anticipation, conditioning of attention, are pertinent to the act of scanning; in fact, these represent different aspects of the act. Since they are applicable to the process of scanning itself, they are pertinent both to external and to internal scanning operations. It is believed, therefore, that proprioceptive, interoceptive, and memoric or "central" cues are utilized in directing the scanning process, in bringing the scanning operation momentarily to rest at a particular point or directing it to go elsewhere. Insofar as there are constitutional attention-getters, like bright light or severe pain, scanning will inevitably be drawn to such points. Insofar as there are acquired specifically conditioned attention-getters, scanning will likewise move to them. Scanning moves toward that which is congruent with the established set, and excludes that which is noncongruent. It would be almost equivalent to say: "Attention moves toward that which it seeks, comes to rest momentarily when that which it seeks is found."

If that which one seeks is that which gratifies a need, one has the possibility of seeking that which is not fully real; that which cannot be validated by behavior in this world shared with our fellows or, as Sullivan would say, that which does not achieve "consensual" validation. *Autism would be an instance of scanning or attention operating in such a way as to use those cues, especially interoceptive, proprioceptive, and memoric cues, which have in the past led to objects offering gratification, and which may and often do override the evidence of present exteroceptive sources.*

It would appear then that one of the many ways of possible reduction of autistic trends might be training in the use of external and internal scanning processes which would reveal more directly the character of the exteroceptive, interoceptive, or memoric cues playing a part interfering with good reality testing. Since the determination of reality always depends upon a balance between exteroceptive, proprioceptive, interoceptive, and memoric cues, it is entirely possible that in some circumstances the best way to correct for autism is to strengthen or more sharply define the exteroceptive cues. But if the individual can learn to detect the distorting effect of these classes of internal cues, the exaggeration or accentuation of these may (if an individual is alerted to their significance) enable him likewise to give them a role less destructive to his perception of reality. An example of the former and of the latter procedure combined is Weiner's tilting-chair experiment (40) to help subjects recognize that the pressure on the buttocks, thighs, and legs contributes to field independence, and through systematic training enabling them to become aware of, and hence to discount, misleading impressions and to accentuate impressions which could be used to combat the visual evidence. This is close indeed to the goal of reducing autism through training. In all such experiments, it is of course presupposed that the subject is eager to perceive more realistically. One of us (C.M.S.) has shown in a similar situation that subjects do select out stable proprioceptive cues *without* instructions to do so.

The same constellation of cues could have been used to produce less and less adequate perception if the subject had desired this. Often we utilize techniques of seeing less and less accurately; alcohol, drugs, flattery, are common devices for altering cue balance. Much depends upon the stimuli given, and set would not be effective if sensory material were too strongly opposed to the given set; but it is only by analyzing and utilizing the concept of set (of which volition is one example) that we can study the shifting patterns of cues upon which autism-reduction and the improvement of reality testing can be built.

The relative blunting of the perceptual process to cues provided is the first step toward the process of *scotoma,* or exclu-

sion of sensory evidence. Autism really rides high when a mass of relevant sensory material is effectively excluded. Rarely, however, can the job be done with such complete success. More commonly, we suggest, the task is merely one of relative emphasis. There are many proprioceptive devices for blunting or weakening evidence which we wish to reject. Not only is it easy to avert the eyes from that which we do not wish to see; there are many ways of making the eyes and the other exteroceptors less effective in differentiating stimulus cues; many ways of blunting what would otherwise be clear. One of the simplest is to tighten up a group of striate muscles which are irrelevant to the task. This may operate to overwhelm the perceiver with either massive or undifferentiated misleading information. This "noise" would produce hypertonus in certain regions such as the external eye muscles and the vocal apparatus by which visual perception and appropriate naming of objects could be effectively carried out. This blunting or "dedifferentiation" of visual information need not ordinarily involve actual threshold changes in items or bits of information, but if the positions of eyes or head are altered in this manner the "distraction" due to the overwhelming input of irrelevant energy could well affect thresholds. As a rule the effect is achieved not through threshold alteration but by what Kilpatrick (21) described as the "*B* type of learning." It will be recalled that in distorted-room experiments he found that part of the learning was due to the gradual discovery of "give-away cues," *but* that in some instances the components of the visual field remained essentially the same, but were recast or *reaccented* by the learner. The learner actually came to see the distorted room in a new way. It is this kind of perceptual learning to which we are especially referring here.

THE PROPRIOCEPTIVE "LOCK" ON PERCEPTION

For certain purposes, special importance lies in the fact that in addition to exteroceptive feedback, influencing both motor and perceptual responses, there is proprioceptive feedback directly aroused by perceptual acts themselves, as in the case of the

altered activity of external eye muscles when one has looked too far. There is also interoceptive feedback, as when disappointment, amusement, or rage lead to a type of excitement which interferes with effective eye movements or focusing activities. (See Kubie [23] for a discussion of such factors.) The proprioceptive and interoceptive functions are, however, neglected in much psychological research. The marksman, making his constant error, is seldom alerted to the fact that he can get some information from his trigger finger, from his hand, and from his postural muscles, as to the character of his error; and he may in fact be so painfully alerted to the exteroceptive evidence of his failure to hit the target that his attention is actually drawn *away* from proprioceptive cues that might be useful.

Notoriously, interoceptive sources of information in such cases, the welling up of a blur of confused visceral responses betraying his "disappointment at his failure," may do nothing to correct his perceptual or motor errors. Just as the chronic psychiatric patient keeps up a cycle of maladaptive responses expressive of a chronic maladaptive effort, so many a learner in an experimental task establishes faulty modes of utilization of such perceptual cues as are at hand.

Just as engineers (33, 41) make use both of negative and of positive feedback, so physiologists and psychologists are noting more and more instances in which both these types of feedback occur. Most of the ordinary locomotor and manual responses represent negative feedback in which, for example, overshooting is corrected by a flexion of the overextended member. Positive feedback is exemplified by many exaggerated circular responses, like that of causalgia, and by such common devices (well known to psychiatry) as working oneself to a frenzy of rage or of fear. It appears necessary, however, to note that the cumulative effects of previous feedback responses often become of prime importance, either by working the physiological mechanism to a new level (compare here Helson's adaptation level [17] and Goldiamond's study [14] of the cumulative effect of stimulation) or by involving the phenomena of higher units, the establishment of traces and the consolidation of levels of organized readiness to respond.

Thus far we have referred primarily to feedback operations in or functionally associated with the sense organs that are most directly involved. We believe, however, that the whole body is involved in one way or another. An everyday illustration is the use of gesture to map out a region of reality and by implication to exclude all else as irrelevant or even unreal. The gestures of belittling, averting, sweeping away, washing out, knocking down, or pulverizing that which we do not wish to accept have been well recognized by anthropologists whose studies of gesture and stance show how the world is almost literally made and unmade by the emotionally directed conversationalist. In the recent brilliant work on kinesics by R. A. Birdwhistell (7), we have new evidence of cultural, social, economic, and personal differences in modes of accentuation of reality by the language of gesture. The same sort of thing on a minor scale has been done by Krout (22), who, under the term "autistic gestures," shows some of the devices by which some aspects of reality are accented and others minimized.

The classic in this area is of course the study of "Character Armor" by Wilhelm Reich (29). Within a broad psychoanalytic framework, Reich has suggested that both the striped and unstriped musculature become set in such a way as to perpetuate experiences from early periods, to reinforce and give enhanced life to some of our action tendencies, and to block out or exclude that which is unbearable. The defensive gesture is frequently a chronic warding-off response. The frozen New England Calvinist who cannot face his own emotions may reveal a musculature so locked that it is only by shaking and limbering him up, only by enabling him to strike, to get angry, to vomit, that he can discover what he has been doing to lock his own expressive machinery. Edmund Jacobson's (19) work on "progressive relaxation" has shown that learning to limber up a striped muscle pattern may carry over and unlock also an unstriped muscle system like that of the esophagus.

We have already noted Braatoy's work which revealed that the circular pattern of rigidity in the striped musculature actually served to "distract" or keep attention away from visceral and cortical activities fraught with pain. Indeed, it may be that in

some patients something even more specific has occurred; namely, that the tightening of the arms may be highly specific and symbolic in reference to some specific danger, for example an actual attack. Having defended oneself against an attack, one may defend oneself, as Freud noted, against a memory of it. Defense in all such cases is a genuine example of the process of "distraction," self-initiated and self-maintained.

"UNLOCKING" AUTISMS

At this point we take up, again, the theme of enabling the subject or patient to detect the cues indicative of his own defense operations. He might learn to detect that the body as a whole is tight or that the unstriped musculature is in a cramp-like spasm, or that there is a certain quality of experience present which arises only when certain innervation patterns are maintained for a long time—a peculiar kind of fatigue, not induced by work or exercise but only by this inner turmoil. Or, he might in some cases learn to detect the specific region of the defensive operations, as in the case of Braatoy's patients. The discovery of such inner cues would, as we noted, initiate a "search-set" for a new way of observing this troubling world. The subject might, automatically, like Kilpatrick's subject, see in a new way because the dominant way has suddenly been thrown out and the second most dominant way has taken its place; or, under the strong set to meet reality on its own terms, he might scan for a considerable time, guided largely by a fresh interest in reality. Yet we would argue that even without fresh scanning with an essentially new set, the sheer direction of attention to a tangled mass of sensory cues might lead to learning and to progress toward accurate perception. We have in mind J. P. Seward's (30) experiment which found that visual stimuli behind a ground glass screen which had to be read from time to time without knowledge of results were gradually read more and more correctly. There is a good deal of evidence to show that just making such sensory evidence available and giving it over and over again to the patient observer may gradually lead to a new construction more in line with reality. This method stands in contrast, as already noted, to a method

in which attention is directed to error itself (cf. especially Dunlap [12]). We would argue, as did E. B. Holt (18), that when error has once been detected, the subject is only at the beginning of his learning. Being wrong does not tell one what is right. It merely *starts a new search-set* and a new learning process.

If the subject, utilizing any of the cues that have been described so far—exteroceptive, proprioceptive, interoceptive, memoric—now perceives a little more realistically than before, our primary problem is the possibility of transfer to new situations. There may be devices by which autism generalizes beyond the area in which it has built up. By the same token, the removal of autism may likewise generalize beyond the experience in which the removal first occurred. This is the heart of the problem of getting rid of autistic habits. It is even possible that there is such a thing as recognizing an autistic response by its own intrinsic qualities: "Knowing when we are kidding ourselves." *

SUMMARY

Ordinarily perception is conceived of as a function of *external* sources of stimulation; yet this way of thinking overlooks the enormous number of signals which originate within us and which enter into the perceptual act. Indeed, we are constantly scanning those internal signals which feed into the perceptual system from the autonomic and/or proprioceptive systems. These internal signals can function to either stabilize or distort perceptual acts.

* I think you are hinting at something quite important in the way you have recast my idea. In recognizing that we are deceiving ourselves, there may be two distinct processes. One of these is to recognize the sheer content that does not square with our experience, as when we are autistically overestimating the size of a disc and we feel a bit queasy, knowing that something is wrong. There are memory images, etc., which give the lie to our present perceptual response. We might call this the *content cue*. Second, however, a much broader and more formal process: there may be certain hallmarks of self-deception. They might be proprioceptive; there might be ways of "feeling wrong" which carry over cross-modally in which (for the individual at least) are universal danger signals. Indeed, some of them may not be sensory at all; they might be like Woodworth's imageless thoughts, or they might be like certain schemata which have lost their original sensory character and are like a mathematician's pure guides to classification. (G. M. to C. M. S.)

When an individual utilizes those cues—especially interoceptive, proprioceptive, and memoric cues—which have in the past led to objects offering gratification, more than he utilizes evidence of exteroceptive sources, he is perceiving autistically. To the extent an individual can learn to discriminate and recognize these cues, he can gain greater control over his perceptual system and, hence, become more veridical in his perceptions.

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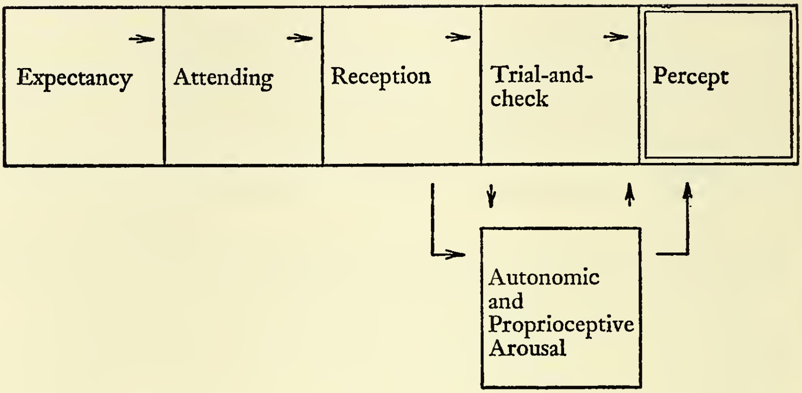
13
Figure-Ground



According to tradition, the problem of figure-ground relationships is confined to the field of perception. There is something "self-evident" in the experience of figure-ground relationships. In our daily lives there are constant transformations and restructurings in our perceptual fields. This process is revealed as the reader of this book reads this page. The reader sees this line of print as figure and the page as ground momentarily; but as he glances over his desk, in the next moment, he sees the same page as figure and his desk as ground. This *shift* from one component to another component in the perceptual field is clearest in the phenomenon of figure and ground.

To what extent are the mechanisms responsible for figure and

ground built into the organism, becoming active automatically through the slow process of physical maturation? To what extent are figure-ground relationships determined by specific learning experiences? The answers to such questions are intricately interwoven, and only careful, systematic experimental study can determine to what extent individual experiences such as those of reward and punishment (pleasant and unpleasant experiences) give clarity, emphasis, and stability to one or another component in a figure-ground relationship. Not only are the answers intricate and largely unknown but the problems themselves are equally obscure. We plan to clarify some of the problems, not all; and to provide a few answers. We would like to provide more than hors d'oeuvres but, alas, the wild game is still uncaught.

We are indebted to the classical studies of Rubin (14) which isolated many of the properties of figure and ground relationships. In his studies a number of nonsense forms were prepared by cutting irregular portions out of cards; these forms were placed before a lantern with green glass. Subjects reported their introspections on what they perceived. From these data Rubin discovered many of the basic features of figure-ground organizations. In summary form, Rubin's conclusions were these:

1. The figure has form whereas ground is *relatively* formless. The ground may have form properties but it is less definite, with weaker contour.

2. The figure has "thing-like" qualities whereas ground appears as unformed material, and once the qualities are experienced they tend to stabilize.

3. The figure appears nearer to the observer than does ground, and the ground appears to extend unbroken behind the figure.

4. The figure is more easily identified; its color is more impressive and it is more likely to be connected with meanings, feelings, and esthetic values.

A classical example of figure and ground is shown in Figure 16. This is Rubin's "twins and vase" example, which is an old Danish design. There is a story connected with this design. Two Danish princes were banished, and it was decreed that no one could have or make a picture of them. One of their loyal followers drew

FIGURE 16. *Rubin's "twins and vase" figure taken from an old Danish design.*

the design shown in Figure 16 to foil the decree. Those who wished to see the "princes" could do so, and those who wished not to see them could see the "vase."

Reversible figures have been known for centuries (28). The ancient Egyptians, Arabians, and Indians used such "puzzle picture" designs as magical devices, and ancient coins have been found bearing reversible figure-ground contours. It is interesting to speculate why the ancients considered these reversible figure-grounds as magical. There is an element of surprise, and occasionally of astonishment, when a naïve person first experiences such a reversal. There is also the curious feature that one sensory

event, *i.e.*, one contour, can contain two distinctly different sensory organizations—it is a great deal like the magician who changes one rabbit into two rabbits.

Our goal is to determine the role that rewards and punishments play in structuring the figure-ground relationship. In the twins-vase example, the princes' followers were motivated to see the twins whereas their enemies were motivated to see the vase. Presumably, each group had had the same amount of experience with the "princes," but one group had found the previous experiences rewarding and the other had not.

As to the role of prior experience, Rubin (14) noted that if a person is briefly shown such a figure several times he will subsequently—and repeatedly—report seeing the same thing as "figure." Sheer experience in organizing figure and ground seems to stabilize the relationship. (Some recent evidence [13] questions Rubin's results.) In this kind of learning of figure-ground relationships, not only is the field structured but there must also be a simultaneous internal strengthening of cues *within* the figural component. Moreover, one cannot separate the "learning of ground" from the "learning of figure" when both features are "learned" contiguously.

VISUAL FIGURE-GROUND

We use the term "learned" reservedly. Hebb (3) presents enough evidence to make it clear that some kind of figure-ground organization is innate, presumably due to autochthonous factors. But *what* is figure and *what* is ground can be learned.

Schafer and Murphy (15) attempted to demonstrate this. Their procedure was to present one of two profiles (shown in Figure 17) at a time. The two profiles could be put together, like two halves of a torn Chinese laundry ticket, so that they formed a circle. These two profiles are like the "vase" and "twins" that Rubin used. If one is seen as figure, the other is seen as ground. Schafer and Murphy presented one of the two faces for 1/3 second in a Whipple-type tachistoscope; then the subject called out the name of the face, guessed one of four numbers (which he believed controlled the next presentation), and the ex-

perimenter called out the correct name and told the subject he had either won or lost. The subject moved a small number of pennies from the experimenter's stack to his own if he won, and put them back if he lost. After 100 trials, the double-face figure was exposed 1/3 second for a series of 32 trials. Mixed in with these test exposures were set-breaking figures which could be seen only one way, and a "phony" face not previously seen. Only six subjects were run, half being rewarded for one face and punished for the other and the other half having the opposite conditions. There was an overwhelming number of reports of the rewarded face in the test trials. All subjects showed the effect. Interview material, taken after the test trials, indicated

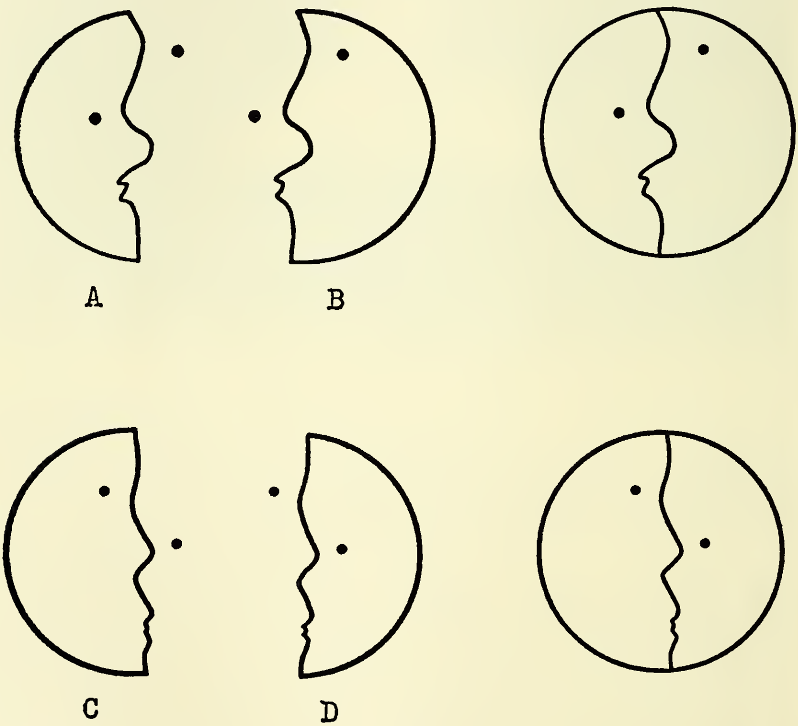


FIGURE 17. *Profiles used in training and testing by Schafer and Murphy (15).*

that subjects often denied seeing the alternative face. There was a stubborn insistence that only one face was present even when the experimenter explained that two faces were present. And, if forced into a corner, the subject would sometimes insist that the alternative (punished) face was "not real" or was a "goof."

Although this study can be criticized validly, a method for studying alterations in figure-ground relations as a result of rewards and punishments was devised. Among the serious errors or weaknesses (we do not completely separate the two) we find the following: (*a*) not enough subjects were run to generalize to other subjects or to secure full stability of results; (*b*) the data were treated as if they were independent, *i.e.*, the data were analyzed as if only one measure had been taken from a large number of subjects rather than as repeated measurements; (*c*) the technique of having the subject name the profiles in the training phase might have produced verbal conditioning of the name of the rewarded profile; and (*d*) profile and direction (looking right or looking left) were perfectly confounded. Schafer and Murphy themselves pointed out many of these factors. On the last point, they suggested that mirror images be used in training and testing.

The challenge of this study was taken up by Rock and Fleck (12). They said they were repeating the Schafer and Murphy study but made several substantive changes. Instead of using a Whipple-type tachistoscope, they used an opaque projector. This change in apparatus produced several effects. Whereas in a Whipple- or Dodge-type tachistoscope there is an illuminated fixation field, which insures that the subject will be light adapted and will not be disturbed by the suddenness of illumination from the fixation field, a projection-type tachistoscope provides no such precaution ordinarily. Also it is quite difficult to insure reliable time exposures, particularly at small time intervals. In addition, the projected image is much larger and consequently more difficult to integrate into a meaningful whole during such short presentations.

Rock and Fleck rightly pointed out that it was not correct to run 32 test trials and analyze only the first 16 after the data were

examined.* They also recognized the need for running a larger number of subjects. Besides the change in type of tachistoscope, these investigators used the letters *A*, *B*, *C*, and *D* instead of giving names to the faces, arguing that these would be easier to learn and would avoid the problem of affect already attached to real names. They also gave a test between training and testing to see if the subject had learned the names, this test continuing until the subject named ten of the profiles in a row correctly or until the experimenter despaired of his learning the names. (This "name learning" may have extinguished the experimental effects.) Nine subjects were run in the experimental condition but only six reached the criterion, three subjects being rewarded for a right-pointed face on one test figure and for the left-pointed face in the second ambiguous test figure, three other subjects receiving the opposite training. Three subjects were rejected because they gave no evidence of learning the correct names. Four subjects were run without rewards and punishments as a control group.

The results certainly did not confirm the results of Schafer and Murphy. Moreover, the one subject who reported predominantly the rewarded profile was also the only one who reported experiencing the winning and losing with a strong degree of "involvement." Unfortunately, this same subject also reported that he often "set" himself to see a face and then reported what he was set for.

Obviously, the Rock and Fleck experiment did not settle matters. Their subjects were too few, and the use of a projector introduced more problems than it answered. There seemed to be a fairly straightforward thing to do next. That was to repeat both procedures, the Schafer and Murphy and the Rock and Fleck, using a larger number of subjects. This very necessary step was taken by Jackson (4). A few changes were made in both paradigms. The Schafer-Murphy procedure was repeated,

* Schafer analyzed the first 16 test trials separately from the last 16, since an inspection of his data revealed a "consolidation" of one or the other face at about this point. That is, subjects began reporting only one of the two alternative faces after about the sixteenth trial.

with the following exceptions: A modified Dodge-type tachistoscope was used which exposed figures 2½ inches in diameter at a distance of 24 inches; rewards and punishments were increased to fifteen cents (an increase to take care of presumed effect of inflation)—and subjects were paid at least ninety cents for participating; male students from a nearby university were used; the number-guessing and the "phony" face procedure used by Schafer and Murphy (14) in the training were eliminated; and a new pair of faces was substituted because preliminary work revealed a marked directional preference for one of the original pairs (as was also found by Rock and Fleck). On the first 16 trials, nine subjects reported far more rewarded faces than punished faces with two subjects reporting more punished faces and one subject reporting an equal number of each. In all, the rewarded face was reported 105 times and the punished face only 39 times during the first 16 trials. In the second 16 trials, 116 reports of the rewarded profile were given and only 51 of the punished. The χ^2s for these sets of data each were significant at the .001 level of confidence.

Jackson conducted a thorough postexperimental interview with each subject. He divided his subjects into two groups, those who admitted feelings about the winning and losing and those who denied feelings. The group who admitted being concerned gave 176 reports of the rewarded profiles and only 25 reports of the punished, whereas the group who denied being concerned gave only 45 reports of the rewarded and 65 reports of the punished. Rewards and punishments can presumably be effective in directing figure-ground organization only if the subjects feel some affect during the course of the rewarding and punishing acts.

There was a tendency for Jackson's subjects to perceive rewarded faces as "angelic," "happy," and so on whereas the punished faces were more likely to be perceived as "ape-like," "stupid looking," etc. Here we see evidence of changes in the physiognomic aspects as a function of associations with rewards and punishments. Such expressions of liking or disliking indicate affect linkages; that is, such reports reveal how the profiles have

been associated with the subjects' fantasies as we have already noted in Chapter 3. Solley and Long (19) report that subjects produce even more elaborate fantasies when requested.

In a second experiment, Jackson (4) repeated the Rock and Fleck procedure, using subjects from the same population pool that he used in his first study. He used a Keystone Slide Projector with a 300-watt light which cast an image with an 8½ inch diameter upon a white screen 69 inches from the subject. Four additional pairs of profiles were used. Six subjects were trained with two faces; another six received another pair of faces; and another six received a third pair of faces. It was necessary to run 23 subjects in order to obtain 18 who met the criterion for recognizing the faces correctly.

The results of this study corroborated some of the same effects noted by Rock and Fleck. For example, there were highly unequal, skewed distributions of individual scores and there was a large number of misrecognitions, far more than in the repetition of the Schafer and Murphy experiment. A total of 231 reports of the rewarded profiles and 164 reports of the punished profiles was obtained, which was significantly different from chance at the .05 level of confidence. The effects of rewards and punishments in this procedure were decidedly weaker. Jackson attempted to account for this difference in the following manner. He wrote: "Confronted with the difficult task of recognizing projected images in a new situation, the subject is forced to seek some kind of anchorage, some mode of perceiving the ambiguous situation so that his probability of correct identifications will increase. One way of doing this was by consistently looking to a particular side for the profile and responding in terms of a stereotyped position set." Jackson (personal communication) indicated that there was often a startle reaction to the sudden illumination of the projected image. Unless one has taken the trouble to equate the illumination of the fixation field with that of the projected image, then one has the problem of light and dark adaptations with which to contend. Jackson also suggested that the difference between the Schafer-Murphy and the Rock-Fleck paradigms might be due to the difficulties of using a mechanical shutter, as found in a projection-type tachistoscope,

which provides irregular time exposures. The last possibility mentioned by Jackson was suggested by Hochberg (personal communication), who pointed out that if the image is large and the time interval small it is more difficult to integrate the total configurations into meaningful wholes.

In any case, this repetition of both the Schafer-Murphy and the Rock-Fleck studies clarified several important points. The influence of rewards and punishments upon visual figure-ground organization had been demonstrated although Rock and Fleck conclude otherwise. But demonstrations are just demonstrations. They point to an effect but do not "explain" it. Other studies were needed to get at the dynamics (8) of this effect in visual structuring and to test the generality of its occurrence in other sense modalities.

Messick, Solley, and Jackson (7) undertook one such study. It is generally conceded that punishment stimuli can function as "emphasizers" (26) or as "distractors" (16) depending on certain known (and unknown) experimental procedures. These investigators hypothesized that loss of money might act as a distractor. There was good reason for this hypothesis. Both Rock and Fleck (12) and Jackson (4) had noted that a number of subjects described the loss of money as annoying. If so, then it would not be surprising that more rewarded faces would be reported than punished.

In order to unravel some of the knotty possibilities they developed a different design. They wished to test the relative advantages of two hypotheses: (*a*) the *emphasis hypothesis* (that affect will make a given face play the role of figure when the face is paired with a neutral one, while there will be no significant difference between positive and negative affect) and (*b*) the *distraction hypothesis* (that subjects should perceive the neutral face in both the reward-neutral and the punishment-neutral conditions, and neither face more often in the reward-punishment condition). A restricted form of this hypothesis, limiting "distraction" solely to punishment, is the same as the "autism" hypothesis. That is, it predicted subjects would perceive the neutral profiles as figure only in the punishment-neutral condition. Only two faces were used. One third of the subjects were

rewarded for one face; there was neither reward nor punishment for the other (with counterbalanced conditions). Another third were rewarded for one face and were punished for the other. Another third were punished for one face and received neither reward nor punishment for the other.

A smaller number of training trials were given, only ten presentations of each face. Mirror images were used in the training as was suggested by Schafer. However, the rewards and punishments were raised to fifteen cents. Also, the subject was not told to name the faces during training. A total of 54 subjects was run, or 18 in each condition, all of whom were women between seventeen and twenty-nine years of age from a local business school.

Even with this respectable number of subjects, the results were not perfectly clear-cut. A response set to see only one side of the test figure developed quickly, an effect very similar to that reported by Schafer and Murphy (15). However, the ventured hypotheses also applied to the *first* response. Sommer (25) has persistently pushed the use of the first response since it most logically should reflect training, having occurred closest to the trials; the problem of successive dependencies among the test trials was thus eliminated. The data on the first response measure are summarized in Table 4.

TABLE 4

First response data from autism, distraction, and attention (7) study

CONDITIONS	FREQUENCY
Reward	12
Neutral	8
Reward	11
Punished	9
Neutral	3
Punished	15

These data, by and large, seem to accord with the "emphasis" hypothesis. In the reward-neutral condition more subjects reported seeing the rewarded face; in the reward-punishment con-

dition neither face was reported much more often than the other; and in the punishment-neutral condition the punished face was predominantly reported.

Messick *et al.*, rather than stopping at this point, included a short form of Osgood's Semantic Differential (10). Each of the two faces was independently rated before and after the experiment on such scales as good-bad, pleasant-unpleasant, beautiful-ugly, happy-sad, big-little, fast-slow, and so on. The only experimental condition in which there was a significant shift on the semantic differential was the punishment-neutral. This was also the only experimental condition in which the perceptual changes were significant. One might *tentatively* conclude that when there is perceptual learning there is also a shift in "meaning."

This effect has also been reported by Solley and Sommer (24) and by Solley and Engel (18). These investigations were reported more fully in Chapter 7, because children were observed. These experimenters found that the influence of monetary rewards and punishments on visual figure-ground organization changes with age. The younger children (age five to eight) organized the field with the rewarded or the nonpunished aspect as figure, whereas the older subjects (age seventeen to twenty-one) emphasized the punished aspects. Both spontaneous remarks and answers to leading questions, *i.e.*, "which of the two faces is happier," led to the conclusion that the rewarded or the nonpunished face was perceived as happier than the neutral or the punished. To impute "happiness" to a face strongly suggests a "meaning." It also implies that affect was aroused by the operation of winning and losing money.

Indeed, affect arousal is quite important. Since money, music, and other secondary reinforcers are not completely universal in the amount and kind of affect aroused, several investigators used electric shock as a punishing agent. There is nearly universal agreement that electric shock is painful, and the experimenter can easily manipulate the amount of shock given. In addition, it is possible to present the shock at precise time intervals relative to the perceptual material.

The only study of the effect of electric shock on visual figure-ground organization is that of Smith and Hochberg (16). They

presented subjects with improved faces similar to those used by Schafer and Murphy. The faces were either white on black grounds or black on white grounds and were improved in the sense that only one face could be seen at a time. Electric shock (voltage and amperage unspecified) was given contiguously with some faces and not with others. In the test situation, subjects reported seeing predominantly the nonshocked face. Smith and Hochberg argued that punishment contiguous with percepts disrupts full consolidation of perceptual traces. This seems to be a plausible mechanism through which "autistic" perceptual structuring develops as we have shown in Chapter 5.

TACTUAL FIGURE-GROUND

The Smith and Hochberg study led to studies of the effect of electric shock on tactual figure-ground organization. Ayllon and Sommer (1) and McNamara, Solley, and Long (6) quickly extended the Smith-Hochberg paradigm to the tactual modality. Their procedures were described in more detail in Chapter 6 and need not be repeated here. In general, their results confirmed the observations of Smith and Hochberg but indicated a more complex process. The conclusion that electric shock disrupts figural organization was substantiated, although other factors can prevent the disruption or make a noxious stimulus serve as a positive reinforcer (see Chapter 6 on this).

AUDITORY FIGURE-GROUND

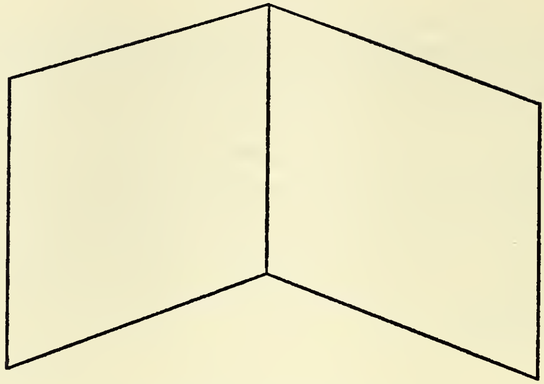
Phenomena of figure-ground organization, similar to visual figure-ground structuring, are observed widely in everyday life. For example, if one has ever attended a large cocktail party, he has observed that he clearly hears the person with whom he is chatting and the rest of the talking is a senseless babble (ground). This effect was studied in the laboratory by Snyder and Snyder (17). They tape-recorded selections from Rachel Carson's *The Sea Around Us.* Half of the selections were recorded with one voice and half with another. These recordings were played to the subject and the experimenter gave him nickels while one

voice was reading and took nickels away while the other voice was reading. The test tape consisted of selections recorded with *both* voices reading different sentences simultaneously. The subject had to reproduce all he heard after each trial (ten seconds long), his reproduction being tape-recorded for analysis. Snyder and Snyder found that subjects reproduced far more of the rewarded voice than they did of the punished voice. From the babble of voices they perceived the rewarded voice as figure and the punished voice as ground. Thirty-one out of 41 subjects showed this effect.

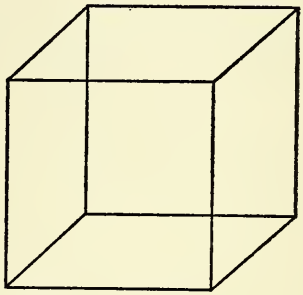
SOME RELATED FIGURAL PROBLEMS

There are some phenomena which closely resemble figure-ground relations but are not the same. We refer to the perception of "reversible figures." In nearly all textbooks, such as Woodworth and Schlosberg (29) or Osgood (9), the phenomena of reversible figures are discussed side-by-side with figure-ground phenomena. The reversible book and cube are shown in Figure 18 as illustrations. As the viewer looks at these figures, the perspective of the figure will suddenly shift. The "ground" remains fixed but the structure of the "figure" reverses very much in the manner of a reversal of figure and ground. The perceptual learning problem here is not whether rewards and punishments can alter figure-ground relationships but whether they can alter the structure of the reversible figure. "Learning" would be evidenced if one aspect of the reversible figure became dominant over the other; the extreme case would be that in which one aspect becomes completely dominant so that the "reversible" figure will no longer reverse.

The earliest experimental work on the role of learning in perception of such reversible figures was that of Wallin (27) who published his studies in 1905. Earlier instances of "natural" learning were observed by Necker, Wheatstone, Wundt, and Mach, but these were not experimental in nature. Wallin, however, carried out extensive investigations using a variety of reversible illusions with subjects of various ages. He investigated the effects of suggestion (set induced by instructions), using



REVERSIBLE BOOK



NECKER CUBE

FIGURE 18. *Illustrations of two reversible figures.*

children as subjects, and the effects of practice, using adults.

Wallin suggested to eight children, between nine and sixteen years of age inclusive, that they would see a given illusion in a certain way; then he briefly exposed the "illusion" and recorded which aspect was reported as seen. These "suggested aspects" were reported about 72 per cent of the time, demonstrating that "set" induced by instructions is a potent variable. The illusion least influenced was the Necker Cube (see Figure 18). In addition, the younger children were more influenced by these instructional sets than were the older.

The practice studies consisted of daily sessions in which two

adult subjects "tried" or "willed" to see an illusion opposite to their dominant manner of perceiving it. As many as 54 to 94 days' practice was given on each of several illusions. Although the learning curves were quite irregular, there was a trend to see the aspect which the subject "willed" to see. The "practice effects" were decidedly weaker than the "suggestion effects," but Wallin noted that this difference might be due to either differences in age of the subjects or motivational differences in the two procedures. In any case, practice, *with intention* to see the nonpreferred aspect of a reversible figure, did alter the perceived figural properties.

In a modern setting, and without knowledge of Wallin's work, Solley and Santos (23) undertook a systematic series of studies on perceptual learning using Necker Cubes. These investigators modified a tachistoscope so that both fields could be simultaneously presented and so that the relative illumination of the two fields could be continuously varied. Improved Necker Cubes were presented for two seconds. In one field of the tachistoscope was a cube improved so that it would almost always be seen as going from right to left; in the other field was a cube improved so that it would almost always be seen as going from left to right. When equal mixtures of illumination were given, a "balanced" cube was seen which would fluctuate in perspective.

The subjects were females, between seventeen and twenty-two years of age, who were attending a business school. On a given trial the subject would be shown one of the two improved cubes or the balanced cube and asked to report in which direction she saw the cube facing. A series of trials was run to determine which aspect of the balanced cube was dominant for a given subject; then reports of the nonpreferred aspect (one of the improved cubes) were reinforced by the experimenter frequently saying, "good," "fine," "uh-huh," "OK," or nonreinforced by the experimenter saying nothing. The nonpreferred cube aspect was reinforced 70 per cent of the time; the other, 30 per cent of the time. Test trials, in which the balanced cube was presented, were randomly interspersed with the training trials. With training the subjects reported seeing the predominantly rewarded aspect in the test cube more and more of the time.

Figure 19 is taken from one of the Solley and Santos studies in which both conditioning and counterconditioning were carried out. This figure shows that both conditioning and counterconditioning were successful in altering subjects' perception of the balanced cube. In fact, three of their subjects reached a level of perceptual learning such that *both* of the improved cubes could *only* be seen as the rewarded one, and counterconditioning was impossible.

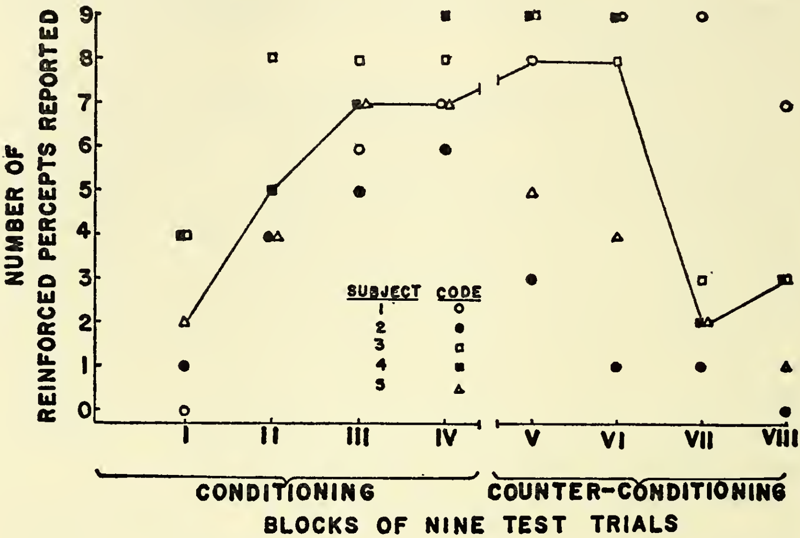


FIGURE 19. *The effecting of conditioning against original preference, followed by counterconditioning, with Necker Cube in Solley and Santos' study (23).*

TABLE 5

Summary of Solley and Santos' (23) data, on first aspect of Necker Cube reported during continuous exposure, in seconds held

STAGE SAMPLED	N	MEDIAN	RANGE
No conditioning	14	5.66	2–20
After training without reinforcement	9	11.00	4–120
After conditioning	10	68.00	18–120
After counterconditioning	5	10.00	8–40

In addition to reports on the balanced cube during the brief two-second test exposures, these investigators exposed the test cube *fully and continuously* after a variety of conditions including no training, training without reinforcement, training with reinforcement, and training and countertraining with reinforcement. In the "no-training" condition, subjects were shown the balanced cube once and only once. In the "training without reinforcement" condition the same procedure was used, but no verbal reinforcers—*e.g.*, the experimenter saying "good," "fine," "uh-huh," and so on—were given when one of the two improved cubes was shown. In the "training and countertraining with reinforcement" condition, one improved cube was reinforced and then (without telling the subject) the experimenter switched to reinforcing the second improved cube.

The average duration of the first aspect reported is presented in Table 5 for each of the major conditions studied by Solley and Santos (23). Conditioning with reinforcement of the nonpreferred aspect of the Necker Cube led *all ten* subjects to perceive the rewarded aspect first upon full and continuous exposure. It also led to that aspect resisting change. Three of the ten subjects did not reverse the cube in the two-minute time limit. After two minutes, the experimenter suggested to these three subjects to "try" to see the cube going the other way. Two of the three replied that they could not possibly do such a thing since the experimenter was "showing them" this one! Both were astonished when the cube finally did reverse, in the middle of their argument that such a thing was impossible.

Which aspect of the balanced cube was first reported, and how long it was held before it reversed perspective were recorded. After conditioning, the rewarded aspect was always reported first; after counterconditioning, there was about an equal reporting of the aspect reinforced during conditioning and of the other aspect of the cube which was reinforced during counterconditioning. After practice without reinforcement, the preferred aspect was reported about 60 per cent of the time. Thus we conclude that reinforcement did alter which aspect of the balanced cube was first reported during full and continuous exposure.

This rigidity in perceiving the balanced cube only in the rewarded perspective was further studied by Solley and Long (21). They repeated the straight conditioning procedure of Solley and Santos. Subjects went through the procedure once a day for three consecutive days, after which the balanced cube was shown continuously. It was hypothesized that this extended training would produce even greater rigidity effects. However, an accident occurred on the first day which proved to be a fortunate event. The experimenter who was to run the subjects forgot his glasses and had to leave the room to get them. The second experimenter gave the instructions and chatted with the subject in the meantime. The first experimenter returned and ran the subject. *No learning occurred.* The second experimenter gave the instructions and ran the second subject. *Learning occurred.* It was decided to finish running subjects this way with experimenters reversing roles on alternate pairs of subjects. Figure 20 shows the results. The subjects with whom the main experimenter chatted—*i.e.*, asked their name, where they were from, where they were working, and so on—and gave the instructions showed learning. The subjects with whom the main experimenter did not chat and to whom the *recording* experimenter gave the instructions showed no learning whatsoever until the third day.

These results teach us an important lesson. Verbal reinforcers are not effective unless there is a rapport established between experimenter and subject. The experimenter who chats with subjects reduces their anxiety—which nearly all subjects have to some extent in the beginning of psychological experiments—and he acquires secondary reinforcing properties by being associated as a complex stimulus with the anxiety reduction.

The continuous exposure data were somewhat disappointing in this study. All subjects who chatted with the experimenter who did the "uh-huhing" reported seeing the rewarded figure first in this phase of the study, but the median time for holding this aspect was only twenty seconds. The other subjects showed no effect whatsoever.

These experiments demonstrate quite clearly that perceptual organization of cues within figures alters under the influence of reinforcements. Although the evidence within these studies does

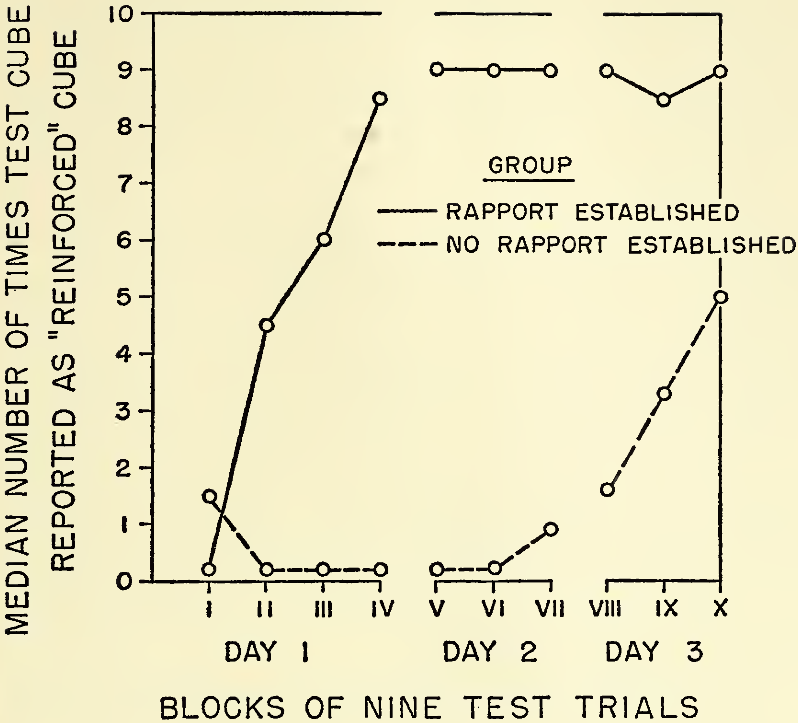


FIGURE 20. *Median number of times a balanced Necker Cube was perceived as the verbally reinforced cube by subjects with whom experimenter had chatted and with whom experimenter had not chatted.* (From Solley and Long [21].)

not permit an unequivocal interpretation of *mechanisms* involved, we can speculate. And we can test our speculations in future experiments. In terms of the conception of perceptual learning mechanisms discussed in Chapter 2, there are two major processes which may be responsible. We have proposed that a percept can become self-reinforcing. That is, the rewarded aspect of the cube has acquired secondary reinforcing properties. The "stimulus" input triggers off the rewarded percept which automatically reinforces the perceiving process which led to its formation, so that the process is immediately repeated and the "reversible

cube" does not reverse. Another possibility is that rewarding a percept reduces the amount of trial-and-check intervening between input and percept, eventuating in no trial-and-check at all. This, too, would produce a stable cube structured in the rewarded direction. We believe that these two possibilities are the most likely.

However, Wheatstone's early work, reviewed by Wallin (27), has revealed that one aspect of a Necker Cube will be seen in preference to the alternative aspect if subjects focus their attention upon certain cues. When a subject reports seeing one perspective, he is informing the experimenter that he has attended to cues differentially. A subsequent reinforcement "reinforces" whatever attentional acts were involved. When the balanced cube is shown, then, there is an increased likelihood of the subject repeating the same attentional acts and of his structuring his percept of the cube accordingly. His search pattern for significant cues has been altered, as we have seen in Chapter 8 on the conditioning of acts of attending; he searches for specific cues, finds them more rapidly, and weighs his percepts more heavily in congruent directions.

It seems unquestionable that figure-ground relations are structured so that there is generally an emphasizing of rewarded aspects and an underemphasizing of punished aspects. It is extremely necessary to recognize, however, that this effect will not occur in *all* experimental conditions or with all subjects. At present we can specify, fairly accurately, the experimental conditions which maximize an "autistic" effect, and we can specify, less accurately, conditions which either negate any effect or maximize a "nonautistic" effect. That is, there are certain ingredients of experimental situations which crucially alter their effectiveness.

Rewarded materials are most likely to be perceived as figure and punished materials as ground, when the following conditions are met in reward-punishment situations:

1. The subjects are actively involved in the training task. That is, there is ego involvement rather than task-orientation. This *may* be the same as saying that subjects should be motivated and

the perceptual materials should be congruent with that state of motivation. Not all subjects are motivated by money, but some are. Many are readily influenced by winning and losing nickels. Similarly, some subjects would experience rock and roll music as gratifying whereas others would shudder to hear it. Either by preselection or by postelimination on the basis of interview data, the subjects must be such that the rewards and punishments are what their names imply.

2. The stimuli to be perceived should be presented so that they can be organized as figure and ground during the time of presentation. If the stimuli occupy the whole visual field, there is little likelihood of reorganization; the use of projectors and Dodge-type tachistoscopes teach us this. Sudden and rapid exposures of a lighted field without previous light adaptation produce a startle effect which disrupts perceptual consolidation.

3. The time-exposure duration must be long enough to permit a perceptual structuring but not so long that a figural-ground reversal occurs. Although nearly all the visual studies reported herein used 1/3 second, Smith and Hochberg (16) have shown that a reversal can occur and *both* faces may be seen in 1/3 second when subjects are set to see both, and many of our own observations show that both faces are reported occasionally at 1/3 second without instructions to do so. Some unpublished work at The Perceptual Learning Project at The Menninger Foundation suggests that 1/5 second is far superior to 1/3 second but that shorter durations do not permit enough consolidation.

4. Awareness also plays a crucial role. Subjects are aware of the perceptual materials and of the reward and punishment stimuli, but they are *rarely aware of the connection between the two.* Although it is not universally true, it appears that maximal autistic perception is obtained if the reinforcement or punishment stimuli are barely in awareness. We might speculate that when this occurs the perceptual materials are being linked with "primary process" mechanisms (2), whereas when the stimuli are well into awareness then "secondary process" mechanisms take over. It is possible that slight awareness of being rewarded or

punished *prevents* a conscious association between perceptual material and reinforcement stimuli. Awareness of such an association may arouse resistance to perceptual alteration.

5. There should be numerous training trials. The best effects have been found with fairly long training. The number of trials can be a crucial variable, as well as total amount of reinforcement.

6. Partial reinforcement appears to be more effective than complete reinforcement. Partial reinforcement does two things: it produces a low level of awareness of association between percepts and rewards or punishments and it produces a greater resistance to extinction so that subsequent transfer tasks are more influenced.

If an experimenter uses these ingredients, he will quite likely find subjects organizing figure-ground stimuli autistically. But the problem of how to demonstrate autism is only one issue. There are other more pressing issues as to *what* mechanism directly effected the autism. Put another way, upon which *stages* of perception and to what *degree* do rewards and punishments exert influence? Do reinforcement and punishment stimuli operate *directly* on perception? Do they operate directly on perceptual expectancy or attentional acts and only indirectly on perception? Do they alter states of affectivity which in turn direct internal "readiness" to perceive? Related issues which also need answering are those concerned with the way in which affect is related to rewards and punishments, and under what conditions perceptual expectancy influences perception of figure and ground.

Only the most tenuous answers can be provided for these critical questions since there is precious little experimental information. The pieces of the jigsaw puzzle fit together something like this: Although people do not react alike affectively to specific rewards and punishments, rewards and punishments are generally connected with positive and negative affect. An individual may or may not be aware of the affect; often, it is necessary to examine spontaneous comments and/or associated fantasy materials (4, 15, 19, 23). Perceptual material associated with affect may be repressed (6). But if the negative affect is itself denied, then the perceptual material will be emphasized (4, 19).

We still have no precise knowledge of *how* affect enters into perception, nor do we know how affect influences perceptual expectancy. But it appears to do so. Indeed, it probably influences perceptual expectancy more than it does perception itself (20). Perceptual expectancy moves in the direction of rewards and away from punishment (5, 20, 22). However, it probably functions as a mechanism in altering perception of figure and ground only in extremely impoverished or destructured stimulus situations. This is probably because perceptual expectancy (or "hypothesis," "set," or "readiness" if one prefers) is a passive mechanism different from intention (11). It is only when there is a minimum of stimulus information that expectancy structures perception, whereas intention to act one way or another in accordance with one's expectancies has a more positive effect in guiding perception. As Postman points out, it is likely that memory is more easily influenced than perception just because perception is ordinarily more firmly *structured*. From this standpoint thought and imagining may be still more amenable to the control of affect than memory can ordinarily be.

Many more studies are needed before we can answer our crucial questions. There is a long journey ahead and we have only taken the first step. As Santayana said, our knowledge is a smoky pine which lights the path but one step ahead.

SUMMARY

We have not implied that figure-ground organization is all there is to the final structuring of percepts; there is much more to the final structuring process than that. We have concentrated upon this aspect of the final part of the perceptual act primarily because (*a*) figure-ground organization is extremely fundamental to all perception and (*b*) more research on perceptual learning has been done in this area than in other areas of perception. It is instructive to examine this rich area.

The effects of learning upon figure-ground organization have been studied in visual, auditory, and tactual modalities. In general, the results of research have shown that what is figure and what is ground is learned; at least this is true of reversible figures.

These reversible figures are such that either of two aspects can be figure. If one aspect is rewarded and nothing is done to the other, then the rewarded aspect is predominantly perceived as figure. The effects of punishment are not as simple. Here one must examine more closely the operations involved in associating the noxious stimulus with the percepts. In avoidance training, the threshold for the percept which acts as a signal for avoidance is lowered and it tends to be figure; in "no escape-no avoidance" training, the threshold for the percept associated with noxious stimulation is raised and it tends to be ground; in escape training, the threshold for the percept associated with punishment varies widely from individual to individual, depending to a considerable extent on the efficiency of escape and on whether or not the individual *tries* to escape.

To complicate matters still more, the effects of rewards and punishments change with maturation of the individual. Children between the ages of five and eight inclusive tend to structure rewarded stimuli as figure and punished stimuli as ground; they operate at a primary process level of organization. On the other hand, adults tend to structure stimulation more in terms of a reality principle in that percepts which signal punishment as coming are structured as figure if the punishment can be avoided.

At any age level, however, there are wide individual differences in modes of regulating or controlling affect aroused by rewards and punishments, or by motivation; this control of affect is an important variable in predicting what will become figure and what will be ground.

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14

The Place of Consciousness and Conscious Meaning in Perception

Throughout this book we have attempted to evade two important problems, most likely without a great deal of success. Avoidance of problems does not solve them; it only delays the attack. Consciousness and meaning are the two problems which we would prefer to avoid, largely because if we discuss them we are quite likely to be charged by our fellow psychologists with being "mentalistic," "anachronistic," or "tenderminded." * We believe, however, that a good solid case can be built for including these concepts and their implications within the framework of scientific psychology.

* C.M.S. is talking for himself. G.M. is not interested in such charges. But both authors agree that both "consciousness" and "meaning" are much too vast as psychological problems to be dealt with adequately in a book on perceptual learning.

WHY MUST WE CONSIDER CONSCIOUSNESS AND MEANING?

With Hebb, we agree that behavior which is called conscious or voluntary should be included in scientific psychology, that "these two terms are not in good standing in modern psychology, and yet they refer to an important psychological distinction: not only for the clinic, where it is fundamental, but even in the experimental laboratory, where for example the differences in conditioning voluntary and involuntary responses are well known. It is not important whether one is to continue using the words conscious and voluntary in psychological discussion; it *is* important to have the distinction to which they refer made explicit, and to be able to deal with it theoretically" (14, p. 144). Even Skinner accepts the notion that consciousness is a legitimate object for investigation:

> Behaviorism has been (at least to most behaviorists) nothing more than a thoroughgoing operational analysis of traditional mentalistic concepts. We may disagree with some of the answers (such as Watson's disposition of images), but the *questions* asked by behaviorism were strictly operational in spirit. I also cannot agree with Stevens that American behaviorism was "primitive." The early papers on the problem of consciousness by Watson, Weiss, Tolman, Hunter, Lashley, and many others, were not only highly sophisticated examples of operational inquiry; they showed a willingness to deal with a wider range of phenomena than do current streamlined treatments, particularly those offered by logicians (*e.g.*, Carnap) interested in a unified scientific vocabulary. . . . The problem of subjective terms does not coincide exactly with that of private stimuli; but there is a close connection. We must know the characteristics of verbal responses to private stimuli in order to approach the operational analysis of the subjective term (54, pp. 271–272).

If men of the stature of Hebb, Skinner, Lashley (34), and Tolman (61) can dare tackle the problem of consciousness, then we too can have the temerity to follow their lead. We begin

with a simple point: Throughout the literature on perceptual learning we have found innumerable studies in which subjects were queried as to what they were aware of during the studies, and time and again it has been found that results have co-varied with verbalized reports of awareness. Often subjects who reported being aware of what was happening were influenced one way in perceptual learning—*e.g.*, punished stimuli dominated figure-ground organizations—whereas subjects who did not report being aware of what was taking place were influenced in exactly the *opposite* direction—*e.g.*, neutral stimuli were dominant over punished stimuli. Throughout this book we have tried to stay at a simple observational level. This has been grossly dissatisfying; the operations and their results merely inform us that something is happening and we are left in the dark as to what this is. If, as Skinner remarks, there is a connection between private stimuli (or events) and verbalized reports, then we must conclude that consciousness of what is going on in a perceptual learning experiment is an extremely important variable. Further, we cannot possibly assess *how* consciousness is a variable (either dependent or independent) unless we theorize about consciousness, *i.e.*, we admit "consciousness" as a construct into our system of knowledge about perception and learning. We personally cannot accept a psychological system, as did Hull (23),* in which consciousness is unimportant. In addition, we have implied throughout this book a definition of perceiving as the structuring of stimulation. We have not defined a percept as a structure in consciousness; yet there *is* the problem of how an individual knows *when* to stop structuring stimulation. Is it when the structure emerges into consciousness? Is structuring itself the mechanism of building consciousness? Can we "perceive" without being conscious of having perceived? All these are questions we have sidestepped but which we cannot continue to ignore. We agree with Freud: "The problem of consciousness

* In all fairness to Hull, he does state quite precisely the conditions under which consciousness is admissible as a scientific construct, *viz.*, that consciousness be an event, observable or intervening, which is deducible from postulates of a system or that it have implications for other events in a system. As he noted, his system had no legitimate place for it.

is . . . less *a* psychological problem than *the* problem of psychology" (8, p. 611).

This is also true of the problem of "meaning." As Osgood says (38), perception and meaning jointly occupy a no man's land between input and output, between stimulation and response. Can one truly separate the two, as Osgood attempts to do, or does every instance of perception automatically involve meaning in some form or another? If the two are different, how is it that meaning affects perception and vice versa? Is conscious meaning the same as unconscious meaning, or are they different? What is the relationship between consciousness and meaning? These and other important questions about meaning link it to perception; one can scarcely talk about one without also talking about the other (7, 42). Yet, the problems of consciousness and meaning are unsolved problems, although newer developments in psychoanalytic theory (*e.g.*, 28), in existential philosophy (*e.g.*, 51), and in physiological psychology (*e.g.*, 9, 10, 14, 15, 16, 17, 22, 29, 30) are casting new light and there are at least good possibilities for a solution. A revitalized interest in meaning is stimulating new research on old problems (*e.g.*, 40). In short, the outlook is bright although mountainous difficulties are still in the way; the *Zeitgeist* is ready for another onslaught.

CONSCIOUSNESS AND PERCEPTION

The intimate relationship between consciousness and perception can scarcely be denied. As phrased by Titchener: "Consciousness is a shifting tangle of processes, themselves inconsistent, and perception is a little bit of pattern unravelled out from the tangle and artificially fixed for scientific scrutiny" (60, p. 128). We agree with Titchener, although we disagree with the point that consciousness or the processes responsible for it are inconsistent; we believe that the processes are complex but not random. We also believe that one must look at the basic problem of consciousness from many theoretical orientations. Consequently, we shall use ideas from the following points of view: behaviorism (Holt, 19, 20, 21; Tolman, 61, 62; and Skinner, 54); existentialism (Sartre, 51); personalistic psychol-

ogy (Stern, 57); physiological psychology (Hebb, 14; Gellhorn, 10; Kleitman, 29, 30; and Hernández-Péon, 15, 16, 17); psychoanalysis (8, 27, 46, 47, 48, 53); and from individuals such as James (24), Ribot (50), Pillsbury (44, 45), and Angell (2), among others. Choosing an eclectic approach instead of a single theoretical orientation, we must shoulder the responsibilities of eclectics; we must weave together a coherent picture which shows that one position is not fundamentally incompatible with another, that often dynamics translate one frame of reference into another, and that a consistent pattern is being presented.

In a real sense the problem of consciousness strikes at the heart of the modern, operational conception of psychological science. Operationalism is based upon logical positivism, and logical positivism is based upon what are called "observational predicates." "Immediate experience" is assumed, and further is assumed to be either "correct" or at least to contain only constant errors in reflecting reality. We believe this basic assumption is wrong. "Immediate experience" must be questioned, just as the assumption made by Descartes that *cogito ergo sum* must be questioned. The problem of "knowing what is" is the problem of epistemology, and as scientists we should be concerned with that important branch of philosophy.

With Sartre (51) we must reject Descartes' and the logical positivists' * (particularly Kantor's [25] interpretation which is the basis for modern operationalism) notion that we "know" reality immediately.

Sartre (51) and Stern (57) contribute the idea that there are *at least* two levels of consciousness. At the first level, there is nonreflective consciousness, as when you drive down a highway "seeing" trees, signboards, cars, etc., experiencing the world immediately. This is a "purely static prolonging of conscious clearness" (57, p. 474). The states of consciousness induced by mescalin, peyote, and certain mushrooms, as described by sub-

* Wittgenstein (65) has recently and brilliantly begun a new analysis of the problem of the "observational predicate," an analysis which finds much in common with Skinner (54) in that the relation of language to subjective events is stressed, but since this is relatively incomplete we shall only consider the Kantorian position (25).

jects, seem to be completely this kind of immediate consciousness; as these subjects describe this state they are intensely, clearly, acutely conscious of stimuli *as if* the stimuli were a part of them.* Perhaps this is the reason Stern (57) prefers the term "living" for this level of consciousnes. The logical positivists most certainly do not mean this level of experience (consciousness) when they say "immediate experience," yet it is the most immediate experience we have. This level of consciousness, this nonreflective level, is passive, seemingly nonenergetic, and has the characteristics of intensity, clarity, or vividness (45). It is probably at this level that "experience" is isomorphic with brain fields, as Köhler (31) puts it, or that there is *nothing but* a clear structuredness of stimulation such as Gibson (11) assigns to the "visual field." It is also presumably the level of consciousness with which Wundt (66), Titchener (58, 59, 60), and Snygg and Combs (55) struggled; and in some respects (though not in all) it is the "system-consciousness" that Freud describes in Chapter 7 of *The Interpretation of Dreams* (8). Essentially, the only kind of meaning that occurs at this level is the meaning of sensory qualities as Johannes Müller used the term; we directly contact the world through our organs of sense and their specific nerve energies; we "experience" red, green, planes, edges, texture gradients, and so on which have the meaning simply of red, green, planes, edges, textures, and so on. If man were to be conscious at this level only, he would never question the universe, he would never seek to know himself, or seek answers to riddles.

However, as Sartre (51) says:

> Consciousness can know and know itself. But it is something other than a knowledge turned back upon itself (p. liii). . . . [Consciousness is always conscious of something.] In fact, it is by means of that of which it is conscious that consciousness distinguishes itself in its own eyes and that it can be self-conscious; a consciousness which would not be consciousness [of] something would be consciousness [of] nothing (p. 173).

* In his poem, "Ulysses," Tennyson wrote: "I am a part of all that I have met."

The set of events must include all events including itself—the answer set theory found for an ancient paradox. Man is *reflectively conscious;* he is conscious of being conscious, an existential phrase parallel to modern cybernetic feedback systems. It is at this level that a scientist operates; he is not merely nonreflectively conscious of a dial; he is reflectively conscious of his immediate consciousness in that he "reads" the dial and it is his reflective-consciousness that he records, not "immediate experience."

The conceptualization of consciousness as nonreflective and reflective is not unique with Sartre and Stern, of course; one finds essentially the same idea in Tolman (62) when he refers to "conscious awareness." Unless Tolman is thinking of man being conscious of his states of awareness (a lower level of immediate consciousness), his term "conscious awareness" makes no sense. Again, in Bartlett (3) one finds:

> The organism discovers how *to turn around upon its own* "schemata," or, in other words, it becomes conscious (p. 208) . . . one of the great functions of images in mental life . . . [is] to pick items out of "schemata" and to rid the organism of overdetermination by the last preceding number of given series. I would like to hold this too could not occur except through the medium of consciousness (p. 209). [Further, this theory] . . . *gives consciousness a definite function other than the mere fact of being aware* (p. 214). [ITALICS OURS.]

Here we pick up the idea again that awareness (a primitive level of consciousness, of experience) and consciousness (a higher level of experience) are different.

Still farther back in history, one also finds the distinction being made by Leibnitz and Wundt (66) between *perception* or a bare sensory impression and *apperception* or a state in which the structures which are *apprehended* are brought to clear comprehension. And within psychoanalytic theory, one finds Freud (8) making the distinction between "day-residues" or "fragmentary experiences" and fully conscious structures and giving

different dynamics to the two species of consciousness. Zilboorg beautifully describes two kinds of consciousness:

> There is a difference [between consciousness and awareness]. To feel aware of something is a static thing. I am aware of this glass of water. I am aware of this package of cigarettes. If I am under a state of fatigue or if I am drugged or if I am asleep, I am not aware of these things. But being conscious of this glass of water means not only being aware but establishing that relationship between myself and that glass of water which means I do or do not want to drink it, I do or do not want to offer it to someone else, I do or do not want to have it in front of me (67, pp. 59–60).

As Loewenberg (35) puts it, there is a pre- and a post-analytical level of consciousness, an immediate and an analyzed state of consciousness. Throughout many schools of thought runs the common idea that (*a*) consciousness can be conscious of itself and (*b*) consciousness consists of *at least two levels*, and probably more. As Hebb remarks: "Let us start by recognizing that the distinction [between conscious and unconscious] is not between discrete, unrelated states, but between the extremes of a continuum. The important thing is to define the continuum, not to decide just where a line should be drawn and to divide one end from the other, or even to divide it at all" (14, p. 144).

Where should we go from here? Let us explore the possibilities of mechanisms by which these levels of consciousness come about, or as Boring (7) has so humorously phrased it, "What properties would a potato have to have in order to be conscious?" Parenthetically, we should add that we are not fully satisfied by the terms "levels of consciousness" or "continuum of consciousness"; we can see example after example, especially in aphasic and amnesic patients and in normal subjects who have taken mescalin or who are hypnotized, that there seems to be a genuine dissociation between states of consciousness. These terms, "levels" and "continuum," are applicable to each separate state of consciousness but do not hold too well across the different states. Rapaport (47), Schilder (53), Klein (28), and others in the psychoanalytic school are quite explicit on the point that

consciousness consists of several states; as Rapaport says: "the *varieties* of consciousness can, and probably should, be treated as relatively enduring organizations that perform definite functions" (48, p. 170). [ITALICS OURS.] And Schilder writes: "Consciousness builds itself up in a great variety of levels" (53, p. 345). With Rapaport and Schilder we recognize that there are *varieties* of consciousness.

Yet we shall deal only with two kinds in this chapter, the nonreflective variety (awareness, immediate, or apprehension if you prefer) and the reflective variety. The special varieties of consciousness observed clinically are beyond our competence, although as discussed and analyzed by Rapaport (46, 47, 48) and Klein (28) these varieties must be included in the ultimate picture. The mechanisms involved in one variety of consciousness may be quite different from the mechanisms involved in a second; and their functions may be quite different as well.

Mechanisms of Consciousness

In the Titchenerian frame of reference the term attention often was used to refer to consciousness. Thus, Pillsbury writes: "Increase in the degree to which an impression is conscious and increase in attention to the impression are synonymous terms" (44, p. 11). Here the individual is a more or less passive registrant of stimulation, as we saw in Chapter 9; he is "accommodating" to his environment rather than actively "assimilating" the environment into his cognitive system as Piaget (43) describes the process. The environment supplies the energy required for consciousness; relatively little mobile, deployable energy (Rapaport) of the individual is invested. The environment, as we use the term here, refers to potential sources of stimulation, including the individual's self-produced proprioceptive and enteroceptive stimulation.

Since the role of response or movement in consciousness has been a controversial one, it is the first mechanism we shall consider.

Pillsbury (45) gives a good summary of the problem when he writes:

> Much controversy has arisen in the past few years as to whether attention [non-reflective consciousness] or movement is primary. One theory is that attention is due to the motor response; the other that attention is first and the response a mere accompaniment or result. The truth seems to lie between them. The essential fact in attention is the selective preparation. Movements of accommodation and clearness of conscious states are both results of this preparation. The preparation . . . is the outcome of the preceding activities of the individual, near and remote, and of the effects that these activities have had upon the nervous system. . . . As seen by the individual, this is marked by selection of stimuli and by clearness of certain conscious states. As seen by another, attention is a series of movements, a visual fixation, a bodily attitude, or a general strain. Of the effects of the preparation we can never be sure whether clearness or movement comes first. In many cases it can be observed that the stimulus presents itself in some vague way and the sense organs gradually adjust themselves to give greater definiteness of impression. This is the usual order in involuntary attention. When the stimulus is expected, the sense organs are prepared in advance. In that case preparation is usually determined by some memory process which precedes and initiates movement. . . . Thus, preparedness makes for a selection, not merely of sensations, but of ideas and of movements (45, pp. 120–121).

There are a host of ideas in Pillsbury's summary, each of which deserves further exploration. Two camps are formed, one of which says with Ribot (50): "Totally suppress movements, and you totally suppress attention. . . . The fundamental role of movements in attention is to maintain the appropriate state of consciousness and to reinforce it (p. 19) . . . Consciousness is only possible through change: Change is not possible save through movement" (p. 46). The other camp, of which Stagner and Karwoski (56) serve as examples, says that we become conscious of events and then we make responses to them. As Stern

(57) puts it, the individual "clarifies his goal in consciousness" and decides whether to invest further energy in action toward his goal. As Pillsbury pointed out, however, the truth lies somewhere between the two camps. The essential thing is that at a given moment in time the individual is responding maximally to one event rather than another, as suggested by Holt (19, 20); the only difference lies in the "cause" of maximal stimulation. In one instance the "cause" lies in the sheer intensity of stimulus energy that hits our receptors which in turn produces movement to receive or avoid or control the stimulation, as when a loud sound alerts us and redirects our attention. Or we may be carrying out scanning patterns in search of specific forms of stimulation to respond to maximally. In either case, nonreflective consciousness ensues, though in the latter case only when nonconscious expectancies and needs are directing the search.

Pillsbury also stressed that "preparedness makes for a selection, not merely of sensations, but of ideas and of movements." Here he is clearly thinking of the purposive feature of reflective consciousness; the selection is not of immediate, nonreflective experience (consciousness) but is of higher complexities which evolve out of the reflection upon immediate experience. Again let us point out that science is really based upon the reflective state of consciousness; science uses constructions ("reading" a dial necessarily implies the reader's use of a construct, of his not only immediately experiencing a "dial" as a stimulus but also of his reflecting on his immediate consciousness of the "dial" as a dial). Science is the systematic study of constructs, not of realities and not of immediate experience. Reflective constructs which are composed by learning, by energy investment, by energy deployment and not immediate experience, are the bases for science. As James (24) puts it, we have no voluntary control over the selection of events into immediate awareness; we only have voluntary control over the amount of energy that we invest in immediate awareness.

All of this brings us inexorably to the next mechanism of consciousness, that of energy investment and distribution in the production of consciousness of events. In Chapter 9 we necessarily

had to deal with the term "attention," as it was there used synonymously with "consciousness." At that point we noted that Stern (57) was among the first to develop a dynamic, energetic conception of consciousness (or "attention," as he called it). It will do no harm to repeat what he had to say. Stern wrote:

> In the act of attention energy immediately available for the performance at hand is summoned and utilized at once. . . . The state of having energy immediately available is called "tension," and this tension, which is always involved in attention is *psychophysically neutral.** Not only experience, but also those parts of the body which are related to the performance, are tense with respect to what is about to occur. They may interfuse completely with one another. . . . The dynamic structure of attention must be completed by the ever present counterpart of concentration: dynamic inhibition of the other areas of personal activity.
>
> Since the person's supply of energy is limited at all times, concentration upon one area is obtained at the cost of withdrawing energy from others. The sharper the focus directed upon the specific performance, the duller the background into which all the rest of personal existence is thrown. In concentrating closely upon anything, whether internal or external, one sees and hears nothing else that takes place about one; not moving a muscle unless it pertains to the performance, even in holding one's breath temporarily in order to devote all powers with precision to the task † (57, pp. 475–476).

* Here there is a remarkable parallel with some of the newer notions of ego psychology as developed by Hartmann (13) and Rapaport (49). Particularly, we have in mind the idea that the ego has *autonomous, neutral* energy for investment in reality, this energy being deployable in the act of attending, or of being investable in events such as perceptions, memories, and ideas. There is, however, a difference between the concept used by Stern and that used by the psychoanalytic school: the psychoanalysts consider this *neutralized* energy—that is, desexualized energy.

† This resembles Schilder's statement (53): "Consciousness is therefore one phase in the *constructive effort* to gain insight into the world, and it is a sign that a great effort is being made in order to solve specific tasks" (53, p. 345). [ITALICS OURS.]

The idea that consciousness is brought about by energy investment is, of course, not original with Stern, although it finds its first clear and systematic expression in his personalistic theory. Even Ribot (50) wrote that movements or responses maintain and reinforce consciousness; here the source of energy is the energy produced by movement. Also, James (24) wrote of the "effort to attend" which brings an object or an idea into consciousness. The essence of the idea is that stimulus energy being received at a receptor level is usually not sufficient in and of itself to produce conscious perception; additional energy must be supplied, whether from kinesthetic and proprioceptive impulses produced by movement, from need-states, from higher cortical activity, or from several other sources.

This is essentially the problem Freud struggled with in Section F, Chapter 7 of *The Interpretation of Dreams* (8). He noted:

> [Consciousness is] *a sense-organ for the perception of psychical qualities.* . . . Perception by our sense-organs has the result of directing a cathexis of attention to the paths along which the in-coming sensory excitation is spreading; the qualitative excitation of the *Pcpt.* system acts as a regulator of the discharge of the mobile quantity in the psychical apparatus. We can attribute the same function to the overlying sense-organ of the *Cs.* system. By perceiving new qualities, it makes a new contribution to directing the mobile quantities of cathexis and distributing them in an expedient fashion (8, pp. 615–616).

The system-conscious combines mobile energy with the incoming sensory energy; and as Freud also noted, the hypercathexis of energy can come about by the arousal of verbal memories. Consciousness has as its base (*a*) an addition of energy which (*b*) is distributed in some economical fashion in keeping with the personality of the individual.

This is an important contribution from psychoanalytic theory, since it coordinates the personality of the individual with the levels and varieties of consciousness. We are not all equally conscious of the same things nor are we capable of being so;

consciousness here becomes more than epiphenomenon; it becomes a dynamic factor in regulating behavior. Although Freud's conception of consciousness as a "super sense organ" has been criticized (*e.g.*, Klein, Holt),* modern physiological theory and research seem to have found a mechanism for its operation. We find Hebb saying:

> Consciousness then is to be identified theoretically with a certain degree of complexity of phase sequence in which both central and sensory facilitations emerge, the central acting to reinforce now one class of sensory stimulations, now another. The cortical organization consists of a diffuse pattern, diffuse firing in a succession of assembly actions or phases that are organized first in phase cycles (conceptual activities) and then in a series of such cycles that maintain a selective influence on behavior for appreciable periods of time (14, p. 146)

Our modern knowledge of cortical-to-receptor feedback mechanisms allows us to say justly that consciousness is a super sense organ which regulates the entire input of messages. The organism can "defend" itself literally by refusing to accept certain messages.

This "blocking" of stimulation from consciousness can also occur at subcortical levels. Recent studies (17) indicate that cats actively investing attention in looking at mice inhibit or dampen or completely block auditory signals at the sense receptor level and at least at a subcortical level. Similarly, visual input signals can be dampened by attending to sounds or odors (16) or, in the case of humans (15), thinking can block visual and auditory inputs at subcortical levels. These are cases of failure of consciousness of one event through the intense, focalized investment of energy in something else.

This idea of the deployment of attentive energies, as we remarked earlier, is an important psychoanalytic contribution. As work in the field of "personality and perception" continues (*e.g.*, 27, 28), it seems more and more evident that styles of deploying

* Holt's scholarly critique (21) fails to take into account the possibilities of cortical feedback mechanisms; therein lies its weakness.

attention, of investing energy, reflect cognitive structures which guide individuals in their perception-environment accommodations and assimilation.*

Functions of Consciousness

Thus far we have discussed the *mechanisms* of consciousness, or more explicitly we have discussed consciousness as a complex function of motor activity, of energetics, and of certain physiological mechanisms. We now turn to things which are a function of consciousness.

Symbolically,

Consciousness $= f\,(a, b, c, \ldots, n)$

in the previous section, and now

$O, P, \ldots, z = f$ (consciousness).

Stated another way, let us look at the functions of consciousness. Foremost among the functions of consciousness is its biological utility in the individual's emergency situations. In 1907 Angell presented the important idea: "Consciousness is constantly at work building up habits out of coordinations imperfectly under control; and that as speedily as control is gained the mental direction tends to automatism; it is only a step to carry the inference forward that consciousness imminently considered is *per se* accommodation to the novel" (2).

This idea, that consciousness plays a dynamic role in learning *new* tasks or in organizing *new* stimuli, seems to have been picked up by Tolman (61) in his early attempt to develop a behavioristic definition of consciousness. He noted that moments of "consciousness" occur before the organism has developed significance, before a discrimination response is made, during the moment of contact with a new or novel situation; in the oscillation before choice consciousness is to be identified. Later, Tolman reneged on his earlier definition when he wrote: "A few years ago I had the temerity to suggest that such 'looking back and forth' might be taken as a behavioristic definition of *conscious awareness*. This was, no doubt, a silly idea. I would hardly

* We cannot go into this fascinating problem area, since we feel incompetent to deal with the manifold issues of personality dynamics and consciousness, just as we avoided presenting pathological states of consciousness.

propose it now" (62). We agree with Tolman that his idea was "weak" but we do not agree that it was "silly"; as he himself has said, many bad theories are better than no theory since they can be tested and proven wrong, and it does not sound unreasonable that consciousness is a tool in man's coping with new situations. It is precisely at moments of deciding that consciousness can aid us most; if we are able to "clarify our goals in consciousness," to paraphrase Stern (57), before acting then we can act in a more orderly sequence than otherwise. Or to paraphrase Klein (27), "conscious perception is indispensable to the selective adjustment to things." Further, we find Hebb noting that we are especially conscious of

> . . . unusual sensory events. The limen for the unusual . . . remains low. The unresponsiveness to some stimuli that is characteristic of the conscious animal is always for the familiar features of the environment. . . . Empirically, in behavior, the most important mark of consciousness is the continually changing selective responsiveness to different aspects of a familiar environment, the *unchanging* responsiveness to unusual or unexpected events, together with the continual presence of "purpose," "means-end-readiness," or motor equivalence (14, pp. 145–146).

It is by virtue of the fact that unusual events have a sort of "emergency" dominance in consciousness that we can cope effectively with the unusual or unexpected.

It is also the function of consciousness to produce a psychological future of experience. By consciously recalling past events, we project our psychological time element into the future and can "try out" various combinations of past experiences in advance of physical action. This is what Stern was referring to when he wrote: "During an act of attention, consciousness possesses a peculiar dual alertness for both that which is given presently and that which is expected next. Fulfillment and the demand for fulfillment are always present in experience at the same time" (57, p. 474).

This quality of consciousness was also noted by Katz who said ". . . a fully conscious individual not only has experiences,

but is clearly aware of having them. He knows that he 'intends.' He can stand off from his experiences and make them objects of his reflection" (26, p. 79). In this way, past "consciousnesses" (experiences) can be examined, or reflected upon, so that the psychological future becomes a projected reality for testing future reality. Man is no longer a slave of the past or of the present, but becomes a master of the future.

Implications of Consciousness for Perception

When looking at a complex issue such as the relationship of consciousness and perception, a broad hypothesis is often a good place to begin; this provides a working base from which elaborations can be made. We choose to begin by noting that we neither perceive all that we are conscious of nor are we conscious of all that we perceive. Let us try to defend this proposition, and in defending it explicate what we believe the consciousness-perception relationship to be. A diagram may be of some help here.

In Figure 21 we have tried to show that we can perceive with reflective consciousness, nonreflective consciousness, and uncon-

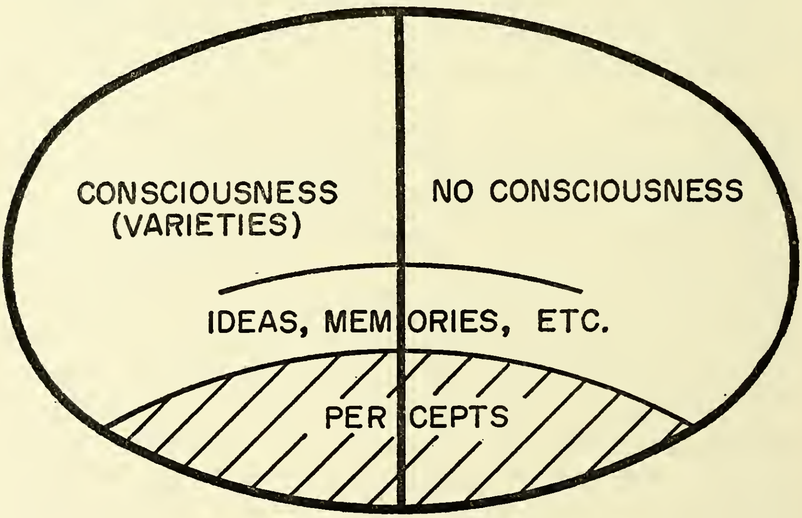

FIGURE 21. *Diagram of hypothetical relationship between percepts, memories, ideas, and types of consciousness.*

sciously. On the other hand, what we are conscious of at a moment may not be perceptual in nature; at a given moment we may be so highly conscious of ideas, as when we are engrossed in thought, that we are oblivious to potential perceptual stimuli. Levels and states of consciousness embrace more than perception; and perception itself can occur without consciousness, at least as we have conceptualized perception. Stimulation can be received, structured, and given meaning *without* the individual ever being conscious of perceiving anything (see Klein, 28). Experimental evidence of this lies largely in certain types of so-called "subception" experiments.

In many so-called subliminal or subception studies, stimuli are exposed tachistoscopically well below the point at which the individual can accurately identify the stimuli 50 per cent of the time. In these studies, duration-time exposures are given; and the individual is aware or conscious nearly 100 per cent of the time that *something* was exposed. In other studies, however, a *continuous exposure* of stimuli is given by projecting pictures on milk glass screens which are flooded with light or by showing red pictures under infra-red light. By using these techniques, stimuli are continuously exposed below the threshold of consciousness. These latter studies are what we refer to as experimental evidence that stimulation can be received, structured, and given meaning without the percept ever being in consciousness. Given this orientation, the term "subception" becomes superfluous, although the functional use of percepts out of consciousness and in consciousness may certainly be different. As we said earlier, events in consciousness can form a projected future and can be valuable cues for volitional actions; perceptual events out of consciousness can probably never be used in determining voluntary actions.

It is not by accident that both Hebb (14) and Penfield (41) discuss the physiological mechanisms of consciousness and voluntary actions concomitantly. The physiological mechanisms of consciousness appear to be precisely those required for voluntary actions. These mechanisms are indeed complex, but as we read Gellhorn (10), Hebb (14), and Penfield (41), they seem to reduce to the *interchange of impulses* between the hypo-

thalamus, the cortex, and the reticular system of the brain stem. The state of this complex interchange seems to correspond both with consciousness and with voluntary control of behavior. By "voluntary" behavior we mean simply that an individual can carry out that behavior on request either by others or by himself (the meaning used by Penfield).

As to how consciousness and perception are connected, Gellhorn (10) gives us some clues. Sensory projection areas of the cortex can be activated without the activation of the cortical-hypothalamic-reticular system (the primary mechanism of consciousness) and vice versa. As we pointed out earlier, stimulation can be received and structured and given meaning without consciousness being involved, and consciousness can occur, as of ideas or memories (41), without perception of an external stimulus being involved. Although there is overlap of the two systems, perception and consciousness, they do *not* completely overlap.

There is evidence that specialized cells in the sensory cortex are activated only under conditions of "attention" in which the mechanisms of consciousness are operative. Hubel, Henson, Rupert, and Galambos (22) report that 34 per cent of the auditory cortex of cats cannot be activated by auditory sounds at all, that about 14 per cent can be activated by auditory signals under all conditions (even when the animal is asleep), and that about 52 per cent of the auditory cells are activated by auditory signals *only* when the animal is "attending" to the sound source. The exact percentages are not so important as the crucial point that cortical cells involved in perception can be activated only when "attentional" or conscious mechanisms are active.

In these studies and in others reported by Kleitman (29), one must distinguish between "consciousness" and "wakefulness." As Kleitman says: ". . . the term consciousness has often been equated, by myself and others. True, some aspects of consciousness are also found in wakefulness, but only in acquired wakefulness, which depends on the cerebral cortex for its development and maintenance. . . . However, consciousness and even acquired wakefulness are not synonymous" (30, p. 358). A person may be asleep and yet be dreaming (a form of conscious-

ness); or a person may be awake and yet have several levels of consciousness or not be conscious of some things at all.

THE NATURE OF MEANING

Our first problem, that of consciousness, is not solved; at best we may have integrated some diversified facts and opinions which cut across theoretical boundaries. Recognizing that the first problem is not solved, we humbly turn to our second problem, that of meaning. What is meaning; what is its nature? This is a philosophical and psychological problem—like that of consciousness—which bears peculiarly upon the problem of perception and generally upon any analysis of behavior. Like consciousness, we believe meaning can and must be included in the science of psychology.

Tackling this problem is like entering a greased-pig contest; there is no guarantee in advance that the pig will be caught; but we shall try because we must. The development of the perceptual world consists simultaneously of the development of stimulation structures (or of habits of structuring stimulation) and of the development of meaning. It is a rare occasion when we, as adults, perceive anything without some meaning. Osgood (informal communication with C.M.S.) challenged the word "rare," claiming it *never* happened; or, operationally, he could not think of an instance of perception without meaning, although he could think of instances of meaning without perception.

Meaning is more generally extended than is perception; yet we are primarily concerned with it in relation to perception. We shall focus upon this relationship, although we must necessarily not ignore the fuller implications of meaning. Let us proceed by analyzing the meaning of several events; this procedure will not define meaning in and of itself but will lead to a definition. (We shall use the first person singular "I" here in place of "we" since we wish to stress meaning for an individual.)

First, I look at a chair (a physical object). What is its meaning to me? It is something to sit on; it can be lifted, moved, turned around; it can be stood on as in taking lights out of a ceiling

fixture. In short, it is an object for which or to which I can carry out various activities. As I enter a room and see this chair, I feel that it is "sit-on-able"; and most likely this meaning lies largely in all the responses, or fractional parts thereof, that I can carry out with or to this chair. This is the chair's Meaning *A*. But it has other meanings as well. As I touch the chair or grasp its back, I feel that it is hard; as I look at the chair, I see various shades of brown and various textures, I see parts and part *aspects* articulated together into a cohesive whole which is figural in contrast with the ground of the wall behind it. These aspects of the chair have little or nothing to do with the chair's Meaning *A*. This is Meaning *B* which is largely perceptual. Meaning *B* can be further divided into two subtypes, Meaning B_1 and Meaning B_2. My immediate consciousness (nonreflective) of the chair is composed of colors, textures, planes, edges, and surfaces which have figural properties; this is Meaning B_1. My reflective consciousness is that this is a cohesive whole, a chair, an object, a physical entity. This is Meaning B_2.

The reader may have strong objections to all this, but let us proceed with a couple more examples before defending our analyses against possible objections.

Last night I saw a sunset. What is its meaning? Can we show that our three types of meaning hold? What can I do with a sunset? I can paint a picture of it; I can relax while looking at it; I can sit and meditate while viewing it. The responses which are elicited by the sunset are its Meaning *A*. But how is the Meaning *A* of the chair different from the Meaning *A* of the sunset? The two response-oriented meanings are different to the extent that there is no overlap in the elicited responses, as shown in Figure 22.

To the extent that I differentially behave in the presence of two physical events I am distinguishing the two events' meaning.

Now, what is the Meaning B_1 and Meaning B_2 of the sunset? As I first look at the sunset I am aware of a riot of bright colors. I am nonreflectively conscious of a spectrum of colors which weave and move. This is the sunset's Meaning B_1. As I continue looking, I see a purple face etched in the clouds, or a flock of sheep; I become aware of feeling relaxed. This is the sunset's

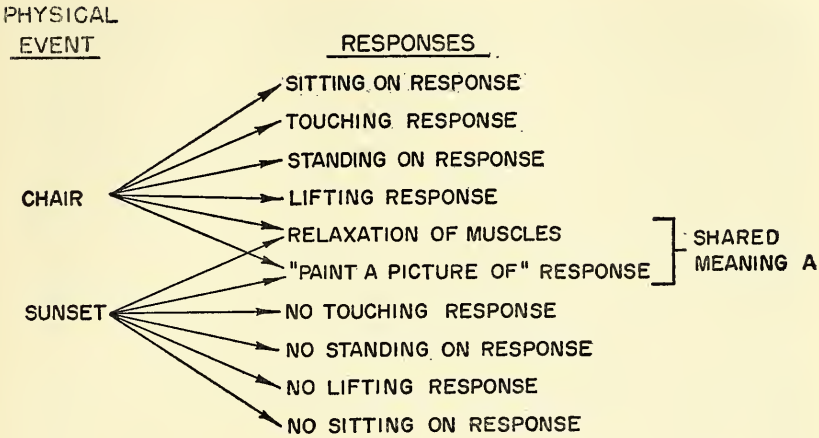

FIGURE 22. *Diagram of how a "chair" and a "sunset" share response meaning.*

Meaning B_2. It is reflective differentiation and integration of what I was, a moment before, merely aware of. The Meanings B_1 and B_2 of the chair and the sunset are different to the extent that I differentiate between their sensory qualities.

Let us take up one more example, that of a spoken word "truth." What is its meaning to me as a listener? In the process of socialization and learning I have learned to give other words following this word in my speech responses; society has reinforced certain responses to "truth" and not others. The word "truth" elicits whole or fractional speech responses as well as other forms of behavior. This is usually called the "semantic meaning" of the word, but in our terms it is Meaning *A*. The meaning of a word is what you do with it; at least this is part of its meaning.

As a spoken word "truth" occurs in the context of other verbalized words. I hear all these words and the word "truth" takes on meaning from its context; just as I often know the meaning of a strange and unknown word from its context while reading. The word "truth" also elicits images of the Statue of Liberty, of blind justice, of my father spanking me for not telling the "truth." I differentiate between this word and other words to the extent that they elicit different memories. Meaning B_1

rarely occurs with words—probably only when learning a strange or foreign word—whereas Meaning B_2 occurs much more often.

We promised that we would make a more thorough theoretical analysis; we return now to that promise. Once again we choose an eclectic course drawing upon Titchener (58, 59, 60), Boring (6, 7), Higginson (18), Piaget (42, 43), Ogden and Richards (37), Malinowski (in 37), Osgood (38, 39, 40), and several psychoanalysts including Freud (primarily 8) Schilder (53), and Rapaport (46). To each of these we are indebted, although we alone are responsible for our main position.

A good starting point for our theory is Boring's (5) concept of successive differentiations within the individual. Between reception of a stimulus and overt behavior there is a succession of differentiations occurring which we have diagramed in Figure 23.

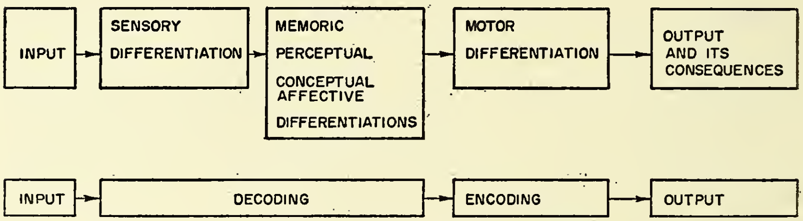

FIGURE 23. *Two ways of diagraming the sequence of events between input and output.*

Following the input of a stimulus into the system, the individual differentiates, to varying degrees, the stimulation qualities of the received stimulus to the extent that his nervous system permits. The results of this differentiation are transmitted, probably as difference values (relativity of stimulation values is important here), to the next system where these difference values are integrated into systems of perceptual, memoric, and conceptual units with new differentiation taking place between the units of these systems. Once again difference values are transmitted and integrated into units of the potential behavioral system where responses are differentiated in incipient form. Difference values of this process are integrated into some final set of values which determines a response family hierarchy. Each

of these points of differentiation and integration represents a node (42) of a well-organized meaning system. Meanings viewed this way are successive parts of an open system (5) in which there is an anisomorphism between successive nodes.

Each meaning node feeds back upon its predecessor, as we have shown in our diagram, governing to some extent subsequent differentiations within the prior nodes. Once we have made a perceptual differentiation and integration we become oblivious of subsequent sensory differentiations which are unimportant for that differentiation. To the average man, a tree is brown and of a certain shape, whereas in actuality (physical reality) the tree is every color in the rainbow and with dynamic form. Seeing (differentiating sensory qualities) the reds, greens, purples of the tree is unessential for the average man in perceiving a tree, whereas for the artist it is crucial to make such sensory differentiations in perceiving a tree. The average man and the artist differ in their meaning of a tree to the extent that they make different differentiations of the qualities of the tree. The range and complexity of the motor differentiations one would make to his perception of a tree, in turn, restricts or enlarges the range and complexity of the perceptual differentiations which are subsequently made. A person who would pour whiskey and all other alcoholic beverages down the drain would not make as fine perceptual differentiations of fine bourbon as would a person who drinks alcoholic beverages. Finally, the motor output and its affective or reinforcement consequences govern to a great extent the probability of sensory input. Stimuli which provide the occasion of a reinforced response are automatically resampled as that response is repeated. We attend to those stimulus sources from which differentiations can be made which govern the emission of reinforced responses.

So far, our theory has been sketched in bold strokes; now we need to fill in the picture with finer strokes and to correct a major oversimplification. The oversimplification is this: according to our diagram, response differentiation (response meaning) is based upon perceptual differentiation. This is admittedly incorrect in many instances, although we believe that it is essentially correct in the majority of instances. It is possible that

differential input of stimulation, as a light versus a forceful tap on the patella, can produce differential responses. Still another example: The pupil of the eye expands or contracts with differential input of light. The differential emission of unconditioned responses on the occasion of an unconditioned stimulus does not imply a perceptual differentiation except in the crudest sense. Differentiation of sensory events, of percepts, and of responses which occur innately, being part and parcel of the individual's biological inheritance, constitutes what might usefully be called *primary meanings*. Through learning, new habits of differentiating and integrating sensory, perceptual, and motor acts are acquired, being molded from or based upon the primary meanings.* As we learn to make finer sensory differentiations (11) we are increasing the sensory meaning system; as we modify our acts of perceiving and differentially store memories as referential context for future perceptions we alter the perceptual meaning system (31); and as we learn to make finer and more integrated responses we alter the response meaning system (38, 39, 40).

This presentation of ideas may lead one to think that meaning is divorced from consciousness. Nothing could be farther from the truth. Consciousness can itself be meaningful. It is meaningful in the sense that we can differentiate (reflectively) various levels and states of consciousness. As a differentiated set of events, various levels and states of consciousness are meaningful; however, the meaning of consciousness is more general and broader than most meanings, because it involves differentiating a general quality of some sphere of meaning from the general quality of another sphere of meaning.

The intimate relationship between consciousness and meaning is further developed in some of Piaget's ideas. He writes:

> Consciousness is essentially a system of meanings that may be cognitive (perceptual, conceptual, etc.) or affective (values with a conative factor are always implied in affectivity). These two cognitive and affective aspects of mean-

* Köhler expressed this well when he wrote: "In its gradual entrance into the sensory field, meaning follows the lines drawn by natural organization; it usually enters into segregated wholes" (31, p. 139).

> ing always go together: none is present without the other, although they may be examined separately.
>
> The word "meaning" always implies a signifier that is more or less differentiated from a signified. Signifiers that are relatively undifferentiated from what they signify are determined by "cues" (sensory, perceptive, etc.). Differentiated signifiers may be determined by convention as in the case of "symbols" (symbolic play, imitations, etc.). Studying the development of signifiers, one finds that cues are first, since they are genetically simpler. Symbols appear next, and finally signs * (42, p. 145).

From this point of view differentiation of events in consciousness is meaningful only if the differentiation has implicative or prognostic value for subsequent differentiation. We have tried to express this in Figure 23, but it will do no harm to repeat this point. If sensory differentiation stops at that point and has no implicative relation with perceptual or motor differentiation, then it is meaningless; if perceptual differentiation has no prognostic value for motor differentiation (activity), then it is meaningless. This does not mean that the individual must overtly act or respond before percepts are meaningful; it only means that perceptual differentiation must be implicative for *possible* behavioral differentiations. We may perceive a glass of water, as in Zilboorg's (67) example, and not act toward or with the glass, but we must establish a perceptual-motor relationship based upon our perceptual differentiation of the glass from the table before there is meaning for the "glass."

The establishment of meaning in consciousness may or may not be the same as unconscious meaning. There are countless numbers of things to which we differentially behave on the basis of our memories, consciously and unconsciously. At times we manage to become conscious of events of which we had "forgotten,"

* This use of the terms "sign" and "symbol" is almost the opposite of the use given them by Morris (36). In Morris' system, which we believe to be the more conventional, signs are events which have acquired signal or implicative value that such and such is to follow or will co-occur; symbols are events which the individual can produce (such as speech) and which can stand in place of its referent.

i.e., we had become unconscious of them; these recalled events may still have the same "meaning" they originally had or they may have changed. Unconscious thought processes (8, 46), as revealed in slips of the tongue or symbolic behavior, must be based upon some kind of differentiation between unconscious events. Thinking is surely not just "talking to oneself" as Watson (63, 64) phrased it; thinking must be a complex, sequential differentiation and integration process (a flow of "meaning" in our sense) which *only partially manifests* itself in subvocal verbal-motor differentiations. Unconscious meanings seem to involve the differentiation of affective and drive components of concepts, memories, and percepts; at least clinical evidence (*e.g.*, 8, 46) indicates this to be more true of unconscious than of conscious meanings.

SUMMARY

Our presentation of consciousness and meaning is already in summary form. How can we make a synopsis of a summary? In retrospect our synopsis can best focus on these points:

In discussing the nature of consciousness we have pointed out that (*a*) there is a variety of levels and states of consciousness; (*b*) consciousness is a function of the energy the individual invests momentarily in perceptions, memories, ideas, or other cognitive events; (*c*) consciousness seems to depend upon the dynamic interchange of impulses between the cortex, the hypothalamus, and the reticular systems of the brain stem; and (*d*) consciousness is important through its implicative relationship with voluntary actions.

As for meaning, we have asserted our belief that meaning is essentially differentiation and integration of sensory, perceptual, and motor events which have implicative or prognostic value for other sensory, perceptual, or motor events.

We have tried to present, in concise form, our ideas about the unsolved problems of consciousness and meaning as they bear on perceptual learning; we hope that our ideas have some merit for consideration.

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15

A Final Look at Perceptual Learning

A summary is in order. Many facts and theoretical points have been presented and, we hope, integrated into a meaningful frame of reference. It is time to take a final look at what we have covered and to make an assessment of where research can be most profitably focused. Here we must use a wide focusing lens to obtain the proper perspective; we must look at broad, general principles rather than at highly specific features. The broad strokes sketch the schematic reference vectors of ideas; the fine strokes fill in concrete details.

There can be little doubt that what we perceive is determined jointly by (*a*) hereditary factors which govern the limits and capacities of the perceptual process, (*b*) the cumulative effect of learning operations, and (*c*) the potentiation of one set of factors

by the other. The statement that all perception is learned is just as false as the statement that all perception is unlearned. Nearly everyone agrees today that the truth lies somewhere between these extreme assertions. It would be difficult to prove, but we believe that nearly every act of perception has nativistic characteristics as well as the earmarks of prior experience; the major problem is to understand the interaction of the two factors, ideally by the use of sets of converging operations. While we have admitted that there must be primitive perceptual acts which "exist" prior to learning, we have stressed throughout this book the molding, the modification, the differentiation, and the integration of these basic, unlearned perceptual acts. Learning does not and cannot bring something out of nothing; like a god, create a palpable universe from the nonexistent.

Motivation, reinforcement, repetition, contiguity, and so on are important factors in directing the course which learning will take. Maturation of the individual, on the other hand, seems to govern (*a*) the nature of the perceptual act at the beginning of a learning experience and (*b*) the efficacy of various types of motives and reinforcers. We have attempted to analyze this complex of events in such a way that testable hypotheses could be developed; and we have attempted an integration of experimental data on perceptual learning.

We began this enterprise with a quick glance at the history of perception, in the course of which we noted how as ideas about perception emerged a theory of learning evolved. Indeed, the entire school of British associationism focused upon the theoretical problems of perceptual learning; and although the later Gestalt movement moved more toward a holistic frame of reference, it too included learning. Often this learning was indirect, entering memory and judgment first and through these cognitive functions influencing perception, but it was learning nevertheless. In short, we began by noting that the role of learning in perception had been recognized for centuries and we were not dealing with a recently discovered phenomenon. History also tells us that how one theorizes about the role of learning in perception is intimately affected by how one conceptualizes perception itself.

At this point we noted that the term "perception" is used by various psychologists in two completely different senses. It is used to refer to the *process* by which stimulation is structured and it is also used to refer to the *product* of the structuring process. We proposed that a better choice of terms would be *perceiving* (process) and *percept* (product). This process could be conceptualized as an act which operated upon stimulation in such a way that there was an alteration in the structure of the perceived world, just as a motoric act alters the physical world. Like a motoric act, the perceptual act can be carried out in many ways; and also like a motoric act, it can be analyzed into temporal components. We contended that the perceptual act could best be conceptualized as the following sequence: expectation of stimulation⟶ attending⟶ reception⟶ trial-and-check, along with autonomic and proprioceptive arousal and feedback⟶ final structuring, particularly along natural lines such as figure-ground articulations. As any of these components of the perceptual act become altered through the application of learning operations, the perceptual process alters, and we can say there has been perceptual learning. Ordinarily, the criterion of perceptual learning is a change in the structure of percepts which would not have taken place without the application of learning operations.

However, the parameters of learning operations which are applied to motor activities do *not* carry the same weight in perceptual learning. For example, although positive reinforcers which are applied upon the completion of a perceptual act can positively reinforce that act, they add comparatively little weight if the percept is clear and well structured, since such a percept reinforces its own act. External, positive reinforcers work most effectively when percepts are vague and poorly structured. Indeed, this seems to be the case for most instances of perceptual learning. This is not too surprising. After all, one cannot teach a dog to sit up after he has already learned to sit up; it is the unstructured, the tentative, the incomplete that ordinarily brings the richest yield in studies of learning.

Negative reinforcers, such as electric shocks, chalk screeches on a blackboard, and loud blasts of sound, are more complex in their effects on perception. If they are given at the same instant

that an individual is carrying out a perceptual act, they tend to disrupt the structuring process, just as a competing response can block completion of its related response. Noxious reinforcers also alter the affective context of the learning situation, changing expectancy patterns and points of attention. As a general input of background stimulation, negative reinforcers also change the contrast value of perceptual stimuli. As if these effects were not complicated enough, in the case of negative reinforcers one must take into account the possibility of the individual's escaping from, or avoiding, or having to "take" the noxious effects. As a general rule, it seems that perceptual stimuli, which are associated with noxious stimuli from which there is a possibility of avoidance, are accentuated, more highly structured, and the individual discriminates them more finely. On the other hand, when the individual must "grin and bear it," the noxious stimulation disrupts the perceptual act. As we pointed out in Chapter 6, there are at least ten things an experimenter must take into account in order to predict the outcome of association punishment with perceptual materials. Among these are avoidance and escape possibilities, the intensity or degree of noxiousness of the punishing event, the *CS-US* time interval, the duration of the *US*, and individual differences in means of coping with unpleasant affect.

These individual differences intrude into the picture in still another way also; namely, in the form of long-range developmental factors. Maturation does not end with birth, but continues, probably for many years, past the time when the individual reaches his full stature. There are, correspondingly, long-range changes in modes of perceptual organization. For example, the child becomes progressively less field-dependent as he grows older. And there are even more dramatic shifts in the child's hierarchy of motives and in the relative efficacy of various reinforcers. As the child develops a wider variety of methods for coping with affective situations, perceptual learning shifts.

In spite of the complexity of the effects of learning mechanisms—*e.g.*, motivation and reinforcement—upon perception, we must stress that matters are even more complex in fact. We have oversimplified deliberately for the sake of seeking schemata, frameworks for providing stability to the picture. To those who

say all this is too complex, we reply that it is *not complex enough*.

Indeed, when we come to examine the alteration of various components of the perceptual act we find our analysis of learning mechanisms very incomplete. There can be little doubt that perceptual expectancies, acts of attention, sensory reactivities, trials and checks, and figure-ground organizations are altered through learning. But the precise mechanisms of perceptual learning are obscure. In comparison with motor learning studies, there is a scarcity of available experimental data on perceptual learning. At best we have a large number of demonstration experiments which tell us that something is present which is worth careful investigation, but no one has carried out the patient—should we say "plodding"—research so urgently needed. We need experimental data, collected in a limited number of research paradigms, on the effects of various schedules of reinforcement; of various intensities and qualities of motivation; of the amount of practice; of developmental factors; and of individual capacities for the regulation of affect, to name only a few things which need to be checked on. What we have presented in this book are largely demonstrations; what we have added are guesses as to how the results of such studies are interrelated.

A NEW PERSPECTIVE

During the evolution of our own thought regarding the active nature of the process of perceiving, a change has gradually come over our way of conceiving the process of perceptual learning. The City College studies, such as Schafer's, and the Menninger studies from the early and middle 1950's were conceived in terms of a reorganization of the perceptual field as if the field itself were definable essentially in terms of its contents; that is, as if the perceptual field consisted of colors, forms, objects, meanings, or other "things" and "events" arranged, ordered, or integrated in a particular way. In terms of such a conception, perception is something "received." However active the organism may be in the adjustment of its sense organs and locomotor organs, how-

ever active its pursuit of external reality may be in the process of perceiving, it is still something like the traditional "white paper" or "photographic plate" upon which impressions are made.

In the gradual evolution of our thought we have come to view the act of perceiving as just as fully and completely entitled to the name of "act" as any motor act could be. It is not enough to say that there is an act of attending; this act is an aspect of a broader act or series or system of acts in a perceptual-cognitive act of confronting, coping with, making sense out of and behaving relevantly with respect to the world perceived. This will be true whether we are looking outward through exteroceptive organs or inward through the organs which serve the interoceptive and proprioceptive systems. (It is indeed possible that the traces or engrams of the memoric system are likewise actively attended to rather than simply touched upon, "lighted up," or drawn into the perceptual act; but on this point we are not ready for a theoretical formulation.) The act of perceiving, then, is an organismic response whose fundamental dynamics—including the dynamics of learning—should be comparable with, perhaps identical with, the acquisition of overt behavior acts.

This does curious things to the conception of perceptual learning. From this point of view, perceptual learning is similar to and perhaps identical with the motor learning on which so much research has been done. This necessitates a reformulation of some ideas earlier expressed by one of us and implicitly shared by us and our teammates in the Menninger Foundation Perceptual Learning Project in the years of the mid-1950's. In 1956 G. M. wrote: "This would enable us to take the four decades of research by Thorndike and his students, and gratefully utilize them to the full, simply noting that it was probably not a peripheral act, but the central process that was rewarded and punished in all these studies. In the same way we can take the massive materials of Hull and Skinner and gratefully note that they can without violence be interpreted as reinforcement of perception" (5). According to this view, perceptual learning precedes the acts which constitute motor learning. There is motor learn-

ing because perceptual learning is going on, defining the possibilities and instigating the changing motor responses.

The view, however, which has just been enunciated in the foregoing paragraphs must regard the acts of seeking, scanning, attending—and indeed all the acts and subacts which enter into perceiving—as behavioral responses belonging to the same family as the motor acts which have been studied by the psychology of learning through the age of Thorndike, Hull, Skinner; we are driven by the logic of our own analysis into regarding perceptual learning as a form of organismic learning rather than a key, or guide, or predecessor, or ringmaster according to whose law the acts of motor learning must move. It would appear that we are reaching the conception of a universal psychology of learning based upon organismic concepts, with perceptual learning a *species* within the larger *genus* of acts which undergo modification. We appear then to be recanting, or at least G.M. appears to be recanting, from the 1956 position.

In a world so open to speculations, however, there remains at least one other promising possibility. It may well be that there is, in the living system, no such clear functional separation as is postulated in discussing perceptual *versus* motor learning. It is entirely possible that sense organs, centers, and motor systems are built as they are because the *perceptual* is that which *makes contact* with environmental requirements. The centers must receive and redirect the incoming energies in accordance with a dynamic of perpetual change in the light of experience, and the motor acts must redeploy themselves constantly in the light of both fresh perceptual information and fresh central reorganization. From this point of view, it would indeed be unsound to say simply that perceptual learning is a guiding and controlling force in motor learning; but neither would it be true to say that motor learning is a genus of which perceptual learning is a species. It would follow rather that the dynamism involved in fresh perceiving is an aspect of an organismic readjustment on lines suggested here and there throughout the present book; but at times we actually have more information about the perceptual aspects of this organismic process than we have about motor aspects,

just as at times we have more information about the motor than about the perceptual.

Whether this compromise is accepted or not, there remains a large theoretical possibility that there is still *another* principle at work, a type of perceptual learning which is in no sense motor and which could not logically be subsumed under a general motor learning theory. For convenience let us refer to this as one of the *S-S* possibilities. Let us grant for the sake of argument that there are moments of very high passivity, at least in the margin of awareness, where things lie still and nothing demands action, and perhaps also at times in the central or clearest portion of awareness—as when for example one lies basking in the sun on a hillside on a summer afternoon, picking one's teeth with a straw, contemplating distant clouds. There may be such slight activity as is involved in letting the eyes drift with a cloud, but no observable act of seeking or of voluntary attention. Under these conditions, even when passivity is at its greatest, we believe that some connections are formed; connections between visual materials as in the near-threshold registration of impressions in the Poetzl experiment or in the association of voices with money in the Snyder and Snyder experiment (where voices are heard and money observed but the connection between them apparently remains an almost completely passive connection).

To all practical intents and purposes this would seem to satisfy all requirements of a *S-S* conception of learning; that is to say, one of them present in awareness may elicit another. There seems to be fragmentary evidence that affectively toned *S-S* connections of this sort are more quickly made or are more resistant to "extinction" or "forgetting" than similar *S-S* connections unaccompanied by affect. The tentative hypothesis would then be that if S_1 is followed by S_2 in a condition of predominantly pleasant affect, S_1 will on later occasions be more likely to elicit S_2 than if no such affect had been present. By hypothesis also, if S_1 and S_2 are both continuing through time, both remaining in the field of awareness while pleasantness continues, each of them will have some capacity later to elicit the other.

This sort of learning *may* likewise be brought within the

generic learning theory sketched above, in which it was stated that perhaps perceptual learning is simply a species within the genus behavioral learning. But in fact it would appear to us that the answer is no. It would appear to us that passive *S-S* learning of this sort lacks a very fundamental dimension or parameter of behavioral learning; namely, the active searching or adjusting process which we have found. *If* this relatively passive learning is real, as tentatively we believe it to be, and if reinforcement actually operates under these conditions, then it would seem that it must do so "dynamogenically," the reinforcement acting to strengthen connections in some primitive way. This strengthening of connections would then give us a genuine learning process, but one dependent upon events impressed upon the learner rather than events arising from his own seeking and attending responses. There are reminiscences of Mowrer and other two-factor learning theorists in the formulation we have just offered. There are, however, sufficiently great differences from Mowrer and other learning theorists for us to prefer simply to state this in terms of its possible interest or merit rather than attempting to dissect into detail the resemblances and differences that are apparent from the point of view of modern learning theory.

In recapitulation we incline tentatively at this time to the view that (*a*) there is a universal psychology of learning based upon organismic adaptations; (*b*) since perception is an aspect of a total adjustment process it must exemplify the more general principles of learning; (*c*) since perception precedes central and motor responses, perceptual learning may often be arbitrarily described in terms of the initial phases of a learning process which is then elaborated and continued through central (cognitive) and motor elaborations; and (*d*) there are probably some types of passive perceptual learning, the dynamics of which lacks some, though not all, of the essential ingredients for the more commonly recognized general dynamics found in the learning process. Taking the four principles together, we might suggest the phrase "dynamic associationism" to indicate the active exploratory character of the process by which associations are found under the impact of dynamogenic, affective, and other reinforcers.

FROM PERCEPT TO THOUGHT

The end of this road is the beginning of another. Without trying to predict where it may lead, we share with the reader a few issues which lie ahead.

All our studies show the arbitrariness of the traditional boundaries between perception, judgment, memory, thought, and imagination. There are boundaries; but they are fluid, cloudlike, evanescent. Perceptual responses involve memories and judgments, lead on into thought and imagination; and the latter influence subsequent perception. We seem then under some obligation to suggest (*a*) ways in which the present approach may combine with other present knowledge to guide us into the theory of these complex cognitive functions, and (*b*) types of research investigations which will loom upon us as such a theory takes shape.

First we shall use traditional association theory as far as we may, showing where it is or can be made dynamic in the sense spelled out here, involving active searching and connecting. Then, we shall suggest certain phenomena which point toward the reality of higher levels, more complex integrations—*still* associative and still dynamic, but involving a third principle.

Associative networks (or cell assemblies) must provide for at least three different kinds of connections. They must (*a*) connect new situations with old established response tendencies, as in the manner of the classical conditioning model; (*b*) provide connections between portions of the perceptual response system and other portions of the perceptual response system (that is, form *SS* connections); (*c*) be capable of providing connections between sensory stimulation on the one hand and gratifying and frustrating types of experience on the other, allowing new experiences to be repeated or dropped. It is entirely possible that one or even two of these forms of connection can be subsumed under another form so that there is only one elementary type of association to be formed.

Although all three types of learning are doubtless fundamental, it must be recognized that the *SS* kind of learning can occur only when a relatively complex network of nerve cells has been

established through the evolutionary process. The simplest classical conditioning can indeed probably exist in a very rudimentary nervous system or without any nervous system at all. But it would appear that the networks or cell assemblies permitting *SS* connections must be of some complexity. All the better from our point of view, in terms of our own need to emphasize the isomorphism of inner and outer structure; the capacity of the inner system to mirror the outer system and at times to cast back the reflection again to the outer world, in the sense that the outer world must be so arranged through the organism's own behavior that it will duplicate or mimic the internal arrangements. Organisms are symmetrical not only because space, gravity, and many other realities give an advantage to the symmetrical organism, which is likely to make more or less symmetrical dams, tunnels, nests, etc., because of its own basic symmetry. (To look ahead for a moment: The symmetries in the thought of the child or the man are to some extent derived from the initial symmetries in the universe and to some extent the symmetries built into the child or the man impose symmetries upon the environment, the ecology to which the life adaptation can best be made.) But at the same time there is a "law of *inequity*" as well as equity; a law of emphasis or dominance as well as a law of equality. There must be critical phases and critical responses, depending upon the sheer importance of one kind of stimulation for the organism. There must be ground rules built into the central nervous system which give the right of way to one kind of situation because of its importance, its emergency value to the individual or the race. The law of figure-ground organization and the law to which Russian experimenters have given the term *dominance* in the formation of classical conditioned responses are instances of basic asymmetries of this sort.

So far, we are at the level of simple connection-forming. As shown, however, by Ashby (2) and others who have made mechanical and electronic models of the living system, the time comes when stress must be placed upon the capacity of the part to act for the whole, a basic law of economy in nature in accordance with which any part may take over the functional significance of the system which has been controlling behavior.

There is a sort of surrogate function by which any system can be represented by any of its components. We can see how this operates in the case of classical conditioning, where any aspect of a complex functional whole may trigger the response which is biologically important; on the other hand, we can see how an elementary but fundamental type of thinking arises when a sort of shorthand or simplifying coding process permits this kind of surrogate function.

If, then, a part may stand for the whole, the question arises: What happens when there are two wholes which have many parts in common? A part of one is thus by definition a part of the other. We may then find that, as dominance relations shift moment by moment, a part of one system will be capable of triggering the other system because it has so much in common with it, and at this critical moment we shift from one to the other system. We thus have *association by similarity*, added to the already given *association by contiguity;* or we have a primitive type of *abstraction* based upon similarities or other common features. Momentary shifts in figure-ground relations would appear capable in their own right of exercising a selection among the engram materials which stand waiting, as representing two complex environmental realities to which somewhat similar or overlapping types of response can appropriately be made.

There is considerable danger that the views just expressed will be interpreted in terms of a basic passivism or tendency of the system to do what the environment tells it to do. We recur to the reminder that every excitation, or even every *readiness* for excitation, is an active process. Adrian has reminded us that even in deep ether anesthesia there is "spontaneous firing" of cortical cells. We regard all living cells as active, as having their own explosive qualities, their own readiness to act, their own tensions; their own deviations from that ideal quietism which would make life depend only upon sheer external stimulation. The present conception indicates the dynamic quality in all cells or groups of cells. Shifts occur from moment to moment in the direction of greatest readiness for conduction. Sometimes the excitation leads to circular reflex activity as in a causalgia or a perseveration; sometimes the cycles are long and complex, and it is only after

hours of activity that one comes back again to the starting point. There is always some relative passivity here and there, but never an absolute passivity.

It may be concluded that this purpose requires a certain basic purposivism in the definition of thought. The word *purpose*, however, is liable to some misconstruction. It is true that tension discharges in one direction more easily than another and that instinctual and other lines of most likely discharge have a fundamental right of way, which often inhibits the likelihood of simple cerebral connections becoming effective in their own right. There are varying degrees of tension throughout the body; this is another expression of the dominance principle already mentioned. At the time of the first response to such tension, however, there can scarcely be any clear awareness of the direction in which behavior will move in commerce with the environment. In time some glimmering awareness of environment-organism interaction comes about, and perhaps a glimpse ahead—some prefiguring of future environmental contact. In other words, rather than predetermining action and experience, purpose is born of them.

The experience of the individual, in response to tensions and modes of environmental contact which reduce the tensions, will undoubtedly cause shorter, quicker, and more efficient modes of escape from the tension situation. Consequently, in those types of motivation in which tension reduction may be pinpointed as the central aspect of reinforcement or the basis for a hedonism of conduct, we may say that the organism short-circuits its way toward the tension-reducing situation. With our modern evidence, however, regarding the pleasure centers and with organisms working all day to give themselves those excitations which apparently cause gratification, we would be on safer ground to say simply that certain types of tension reduction are among the many factors related to such hedonic values, to such "pleasures and pains." More and more action systems which are at first affectively nearly neutral, involving sheer distributions of low-order energies within the central nervous system, get connected up with the high-order energy systems related to strong motivation. The organism *builds a value system* for itself. Since there

are, however, interconnections not only between the various parts of the central nervous system but also between all the various parts of the body, including vital organs, striped muscles, etc., we should expect motives themselves to overlap, and we should expect a kind of overdetermination of motives to which the psychoanalysts refer and for which a place was provided by Sherrington's conception of "summation of stimuli."

There is therefore always more in a thought process than meets the eye. There is always greater richness, and in particular a richer surrogate function, than any dream analysis or projective test analysis can ever reveal. Even in the five-year-old the symbolic life has become complex indeed, and the language symbols attached to all the various drive objects which have importance for the child can lead to interconnecting or self-communicating systems which will function in dreams and reverie, even without much renewed stimulation from the outer environment. One can subsist a long time on the accumulated symbolic system associated with the inner recesses of one's own organic existence. A thought can indeed refer to an external object or to an abstraction drawn from the similarities of the various objects, but it is always pushing forward to meet such objects and abstractions by virtue of its own organic stresses and its own value system.

There is a place here for both the complex unraveling of symbols as practiced in psychoanalysis and the quest for formal principles of structure and order, as exemplified in Gestalt psychology. One might take, for example, conjointly, the psychoanalytic study of a painting and Arnheim's (1) interpretation of the structural aspects of the creative act in which not only space but time, motion, shading, color, and symbol are all seen in terms of a complex inner orchestration which, at the same time, creates and comes to terms with a complex outer orchestration given both by the culture and by the human habitat in which the culture has slowly grown. Just as Edith Cobb (4) observes the beginnings of this inner orchestration in response to outer orchestration in very small children, so we may say that all thought tends to become both as simple and as complex as it can be. We are reminded here of Eddington's question as to the orbits of the

planets. To some, the orbit is the shortest path; to others, the longest path which can be taken; on both of these Eddington comments, "I will give you a third rule: the planet takes any course it likes." We may quite properly say that the child is seeking the principle of least action or the principle of homeostatic balance, or is seeking all sorts of biological and cosmic short cuts. At the same time we may say that he is pushing always, in terms of the complexity which his own life represents, to be a little more complex, a little more redundant, a little more elaborate than life requires. Indeed, he is becoming as elaborate as he knows how to be, as tissues daily grow, wait for "assignments," wait for their place in the complex system which is itself constantly seeking greater complexity.

LEVELS

We bit off a rather large order in saying that association psychology could be reconciled both with the complexities of thought and, in particular, with the principle of pressure toward the greatest isomorphism and the highest integration of which the organism is capable. As we see these matters, however, we believe that we have here simply three levels, the first level being found re-expressing itself at the second and third, and the second likewise finding itself expressed at the third level.

There remains, however, one difficult issue to grapple with. In addition to gradual transitions, there are genuine cases of gaps, jumps, stepwise progressions, or quantum principles. We believe that there is a gap of this sort between the *SS* or other ultrasimple cell connections, and the kind of simultaneous solution of many problems which occurs when we are involved in Arnheim's type of Gestalt analysis. That is to say, there are many formal principles depending upon the organism and the material involved, all of which nevertheless have to be simultaneously considered because all belong to the life of the organism. No *SS* principle by itself can ever show us the nature of the orchestration process. We have to have the *SS* patterns in profusion; but then at a certain level of complexity we have to have basic formal laws or asymmetries or structural requirements based on iso-

morphism with the environment, which permit us to leap from the simple to the second-order complexity. In the same way, as illustrated for example in Rembrandt's perception of the meaning of the human face, or Schubert's and Beethoven's grasp of the possibility of transforming a simple melodic line into a breathtaking new vision of life by adding alterations in tonality or rhythm, we have sudden transitions to a higher plane—a plane in which a richer isomorphism with cosmic structure is achieved than sheer Gestalt principles in themselves would require. We believe that R. M. Bucke (3) and other "visionaries" may have overdone the inarticulate and the ineffable, but that there really is in nature—and in human nature in particular—a law of transcendence which says that when you get to a certain level of complexity (we have called this Level No. 2), you then are not only allowed to but are forced (compare a mother robin pushing the fledgling out of the nest) to try your wings in a new way. It is a reconciliation of this prelevel stepwise or quantum-like transition principle with the principle of continuity from very simple working principles that would be our attempt to justify the overbold statement that association psychology points in the right direction but is transcended as one moves on to Levels 2 and 3.

The laws of thought, then, are associative laws; but they involve other principles as well. Many of these principles, known through the history of psychology (especially to Leibnitz, Kant, Spencer, Werner, Wertheimer), press upon us the challenge of experimental work within the framework of the present approach. The role, for example, of dynamogenic and reward-punishment factors in generalization and abstraction, and in symbolization, will greatly enlarge the view that reasoning depends mainly on the elaboration of verbal and other symbols established by contiguity, and structural problems of organization will be richer when a systematic learning-theory approach to study of affectivity is used. The "irrational" aspects of memory, judgment, thought, and imagination, instead of being regarded as "foreign bodies" in the tissues of otherwise "rational" higher mental processes, will be dynamically seen as one with the general psychology of perceiving. In all the rich experiences of organismic needs and impulses the *veridical* aspects of cognition

which keep us sane and reality-oriented will likewise be seen as expressions of our drive-life and, so to speak, our "reinforcement life" as well. It is only when the whole cognitive life has been systematically viewed in these terms that we can tell whether this beginning, anchored in the psychology of perception, is worth while.

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Glossary

Definitions presented in this glossary are adapted from three sources. These were *A Student's Dictionary of Psychological Terms*, 4th Edition, by Horace B. English; *Dictionary of Psychology*, by Howard C. Warren; and the present text. Letters *E* and *W* refer to English and Warren as the source. For more systematic and extensive definitions, see Horace B. and Ava C. English, *A Comprehensive Dictionary of Psychological and Psychoanalytical Terms*. New York: Longmans, Green, and Co., 1958.

Act of Attending: Any member of a set of activities carried out to optimize reception of a perceptual stimulus or to maximize the momentary strength of a percept.

Adaptation Level: The stimuli in a series which evoke a neutral response; the subjective centroid of a stimulus series about which perceptual judgments are ordered.

Affect (E): Any specific kind of feeling or emotion, especially when it is attached to a particular object.

Animism: The belief that many inanimate objects, such as airplanes, clouds, winds, etc., are alive.

Autism: In general, cognitive functioning in which needs, wishes, or affects determine the result more than does reality.

Autonomic Nervous System: The part of the nervous system which supplies the vital organs and smooth musculature with their efferent innervation.

Canalization (E): Progressive shift in differential response to the various means of satisfying a drive.

Cathexis (E): Degree of affective significance or "energy value" of an object, person, or idea.

Cognition (E): Any process by means of which one arrives at knowledge.

Conditioning, Classical: Often referred to as "Pavlovian Conditioning." It is a learning procedure in which a neutral stimulus (called a conditioned stimulus, *CS*) comes to elicit a response (called a conditioned response, *CR*) which resembles the response (unconditioned response, *UR*) normally given to another stimulus (unconditioned stimulus, *US*). The *US* is presented even when the animal does not give a *CR*.

Conditioning, Operant: A learning procedure in which the experimenter alters the strength of an emitted response by reinforcing it whenever it is emitted.

Conditioning, Second-order: Process by which a stable conditioned response serves as a basis for new conditioned responses based upon it.

Consciousness: Immanent knowledge of one's own thoughts, feelings, and existence.

Converging Operations: A set of operations which are used to define a concept.

Core-context Theory: A theory of perceptual meaning espoused by E. B. Titchener which states that at any moment there is a core of stimulations or percepts, to which we are attending, which are given meaning by their context of contiguous stimulations, images, or ideas.

Differentiation: (*a*) To perceive one event as different from another event. (*b*) Discrimination. (*c*) To change from a relatively general state into several more specific states.

Expectancy, perceptual: An anticipation of some future perceptual event.

Feedback: The signals in a system which return (are fed back) to the input. If these signals oppose or inhibit the input, they are called *negative feedback*. If they facilitate or amplify the input, they are called *positive feedback*.

Field-Dependence: The tendency for an individual to perceive one part of a field in terms of the remainder of the field.

Field-Independence: The tendency for an individual to perceive one part of a field independently of the remainder of the field.

Figure: That part of a total perceptual pattern which emerges from

or stands out in contrast with the rest of the perceptual field.

Figure-Ground: A basic perceptual mode of organization in which one aspect, figure, stands out against the other aspect, ground.

Gestalt: (*a*) Literally translated from the German as "form." (*b*) An organized pattern or configuration. (*c*) A theory of psychology, based upon an analysis of perception, forwarded by Wertheimer, Koffka, and Köhler.

Habit (E): An act or response which is regularly or customarily repeated. (Also see $_{S}H_{R}$)

Habituation: Long-range, more or less permanent, adaptation to a stimulus.

Hedonism: The philosophical belief that man and other animals seek pleasure and avoid pain.

Homeostasis: The tendency to maintain a stable system.

Image (E): Experience similar to sensory experience, but arising in the absence of the usual external stimuli.

Imprinting: The one-trial or extremely rapid conditioning of certain behavior at critical stages of maturation when these behaviors occur in the presence of releasing stimuli.

Incentive (E): Any external stimulus which moves an organism to action.

Inhibition (E): The stopping or restraining of a process from starting or continuing.

Integration (E): Process of bringing together and unifying parts into a whole.

Kinesthesis: Sensation resulting from activity of striped muscles or tendons or joints.

Learning: The process by which an act or a response is changed, in a more or less permanent way, by its occurrence in specific situations.

Maturation: Development of the individual by means of natural growth.

Meaning: The differentiation and integration of sensory, perceptual, and motor events.

Motivation: A set of events, produced by either deprivation or stimulation operations, involving internal stimulation, emotional-affective responses, and energization which in turn provides the occasion for the emission of a response or an act.

Need: A state or condition of homeostatic imbalance in an organism.

Perception: (*a*) A process by which stimulation is structured and (*b*) the result of a stimulation structuring process.

Perceptual Act: A process by which perceptual structures respond in accordance with incoming stimulus energies.

Perceptual Learning: A change in the status of the logically inferred perceptual state or process of an individual as a result of successive applications of the operations of a learning paradigm.

Pleasure Principle (E): According to Freud, the striving after pleasure without regard to other considerations.

Reality Principle: According to Freud, the regulation of behavior by regard for reality.

Schema (Schemata): A skeletonized model or outline of past experience, structured in memory, which serves as a frame of reference for fresh perceptual samples or for immediate modes of behavior.

Scotoma: In vision, a blind spot. More generally refers to a loss of sensory or perceptual sensibility.

S_D: In C. L. Hull's learning theory, drive-produced stimuli. In B. F. Skinner's frame of reference, discriminative stimuli.

Sensitization: A long-range facilitation, more or less permanent, of sensory reactivity.

${}_SE_R$: In Hull's learning theory, effective excitatory potential. The immediate potential that a stimulus *S* has for eliciting a response *R*. Also defined as ${}_SE_R = D \times {}_SH_R - I_R - {}_SI_R$ where D is drive, ${}_SH_R$ is habit strength, I_R is momentary inhibition to respond similar to fatigue, and ${}_SI_R$ is conditioned habits of not carrying out *R*.

${}_SH_R$: In Hull's learning theory, habit strength. The strength of the association between stimulus and response.

Specific Nerve Energies, Doctrine of: A doctrine proposed by Johannes Müller which says, in essence, that for each quality of experience there is a different nerve energy. Thus, the eye sees light when stimulated by light, pressure, electricity, etc.

Stimulation: (*a*) Reception of a stimulus. (*b*) The form of energy which a stimulus takes on when it is received and transformed.

Stimulus: A source of physical energy which (*a*) can potentially be converted into receptor energy and (*b*) an experimenter can manipulate directly or indirectly.

Threshold = Limen (E): (*a*) Absolute threshold: limit of size, in-

tensity, position, etc., at which a stimulus becomes effective for conscious processes or behavior or ceases to be effective. (*b*) Difference threshold: smallest difference between two stimuli which can be discriminated.

Time-Error (W): A perceptual error which occurs when two stimuli are presented consecutively. It is positive when the first of two equal stimuli is perceived as greater than the second. It is negative when the second is perceived as greater than the first.

Veridicality: A state of being "correct." More precisely, a condition of the features of perception being in one-to-one agreement with the features of reality.

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